DOCUMENT RESUME

ED 405 178 SE 054 765

AUTHOR	Crelinsten, Jeffrey; And Others
TITLE	Measuring Students' Understanding of Science in Its Technological and Social Context. Volume One: Designing a Suitable Instrument.
SPONS AGENCY	Ontario Dept. of Education, Toronto.
REPORT NO	ISBN-0-7729-9339-4
PUB DATE	93
NOTE	117p.; Also available in French.
AVAILABLE FROM	MGS Publications Services, 880 Bay Street, 5th Floor, Toronto, Ontario M7A 1N8, Canada.
PUB TYPE	Guides - Non-Classroom Use (055) -- Tests/Evaluation Instruments (160)
EDRS PRICE	MF01/PC05 Plus Postage.
DESCRIPTORS	Educational Research; Foreign Countries; High Schools; Measures (Individuals); *Science and Society; *Science Education; Social Problems; *Student Attitudes
IDENTIFIERS	Ontario

ABSTRACT

This document presents the development of an instrument designed to assess student attitudes toward science and technology, and their understanding of certain social issues surrounding science and technology. The document contains two parts. Part 1, the Description of the Project, includes the following sections: (1) "The Project in Brief"; (2) "Background"; (3) "Methodology"; and (4) "Design and Test Procedures." Part 2, A Literature Review on Evaluation and Science, Technology, and Society Issues, includes the following sections: (1) "Introduction"; (2) "Defining Science/Technology/Society (STS)"; (3) "Implementing STS in Science Education"; (4) "The Instruments and the Methods Used in Evaluating Science and Technology"; (5) "Issues on Research"; and (6) "Conclusion." The test instrument, exhibits, and samples from Glen Aikenhead's Views on Science Technology and Society are included in the appendices. Part 2 contains a 109-item bibliography. (ZWH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

A RESEARCH STUDY COMMISSIONED BY THE ONTARIO MINISTRY OF EDUCATION AND TRAINING

ED 405 178

Measuring Students' Understanding of Science in its Technological and Social Context

Volume One: Designing a Suitable Instrument

Jeffrey Crelinsten, The Impact Group
Jean de Boerr, Market Facts of Canada
Glen Aikenhead, University of Saskatchewan

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

C. Moisse

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

Ministry of Education and Training
Ontario

This research project was funded under contract by the Ministry of Education and Training, Ontario. It reflects the views of the authors and not necessarily those of the ministry.

BEST COPY AVAILABLE

SE054465

A RESEARCH STUDY COMMISSIONED BY THE
ONTARIO MINISTRY OF EDUCATION AND TRAINING

Measuring Students' Understanding of Science in its Technological and Social Context

Volume One: Designing a Suitable Instrument

Principal Investigator:
Jeffrey Crelinsten, The Impact Group

Co-Investigators:
Jean de Boerr, Market Facts of Canada
Glen Aikenhead, University of Saskatchewan

This research project was funded under contract by the Ministry of Education and Training, Ontario. It reflects the views of the authors and not necessarily those of the Ministry.

© QUEEN'S PRINTER FOR ONTARIO, 1993

Order Information:

MGS Publications Services
880 Bay Street, 5th Floor
Toronto, Ontario
M7A 1N8

(416) 326-5300
(Toll Free) 1-800-668-9938

Order must be accompanied by a
cheque or money order payable
to the Treasurer of Ontario

Canadian Cataloguing in Publication Data

Crelinsten, Jeffrey.
Measuring students' understanding of science in its technological and social context

Contents: v. 1. Designing a suitable instrument – v. 2. Validating the instrument.
ISBN 0-7729-9338-6 (2 v. set); 0-7729-9339-4 (v. 1); 0-7729-9340-8 (v. 2)

1. Educational tests and measurements–Ontario. 2. Science–Social aspects–Study and teaching (Secondary)–Ontario. I. Ontario. Ministry of Education. II. Title.

LB3054.C36C73 1992 507'.6 C92-092523-5

TABLE OF CONTENTS

PART ONE: DESCRIPTION OF THE PROJECT

1. THE PROJECT IN BRIEF 1

2. BACKGROUND
    2.1 The New Thrust in Science Education: STS 1
    2.2 A New Secondary Science Curriculum for Ontario 2
    2.3 Monitoring Changes in Student Understanding and Attitudes 4
    2.4 The Present Study 4
        2.4.1 Views on Science, Technology and Society (VOSTS) 4
        2.4.2 Project Tasks 5
        2.4.3 The Choice of the Target Group - Grades 10 and 12 5

3. METHODOLOGY
    3.1 A Survey of the STS Evaluation Literature 6
    3.2 Monitoring versus Evaluation 7
    3.3 The Starting Point - VOSTS 8
    3.4 Using VOSTS to Fulfill Project Objectives 10

4. DESIGN AND TEST PROCEDURES
    4.1 Summary of the Design Process 11
    4.2 Initial Consultation and Design 11
    4.3 Focus Testing 13
    4.4 Summary of Main Findings of Focus Groups
        4.4.1 Teachers 14
        4.4.2 Students 15
        4.4.3 Revisions 15
    4.5 Pilot Test
        4.5.1 Setup Procedures 16
        4.5.2 Site Selection 16
    4.6 Summary of Main Findings of Pilot Test 18
    4.7 The Issue of Student Reading Level 19
    4.8 The Final Test
        4.8.1 The Questionnaire 20
        4.8.2 The Sample 21
        4.8.3 Fieldwork Organization and Logistics 24

5. FOOTNOTES 26

PART TWO: A LITERATURE REVIEW ON EVALUATION AND STS ISSUES

1. INTRODUCTION 29

2. DEFINING SCIENCE/TECHNOLOGY/SOCIETY (STS) 30

3. IMPLEMENTING STS IN SCIENCE EDUCATION

3.1 The United States 32
  3.1.1 Forces Influencing STS Implementation 32
  3.1.2 Specific Programs 34
3.2 United Kingdom 34
  3.2.1 Forces Influencing STS Implementation 34
  3.2.2 Specific Programs 35
3.3 Canada 35
  3.3.1 Forces Influencing STS Implementation 35
  3.3.2 Specific Programs 36
3.4 The Less Developed Countries 37
3.5 Teachers' Reaction towards STS Implementation 39

4. THE INSTRUMENTS AND THE METHODS USED IN EVALUATING ST 40
4.1 Terminology 40
4.2 The Domains of Evaluation in STS Education 41
4.3 Evaluation Instruments 42
  4.3.1 Multiple-choice Instruments 42
  4.3.2 Likert-type Instruments 43
  4.3.3 Essay Instruments 48
  4.3.4 Interview Instruments 49
  4.3.5 VOSTS 51

5. ISSUES ON RESEARCH 54
5.1 Testing Cognitive Skills 54
5.2 Gender 55
5.3 Culture 58
5.4 Social Influence/Pressures 59
5.5 Meta-analysis as a Research Tool 60

6. CONCLUSION 60
6.1 Diverseness of STS 60
6.2 Culture 61
6.3 Gender 61
6.4 Local Relevance 61

7. FOOTNOTES 62

8. BIBLIOGRAPHY 62

APPENDIX A.	Final Test Instrument Used in Province-Wide Test March-April 1990
APPENDIX B.	Exhibits
APPENDIX C.	Sample from VOSTS

PART ONE:

DESCRIPTION OF THE PROJECT

1. THE PROJECT IN BRIEF

In 1989, a new science curriculum was established for Ontario secondary schools. A significant component of the new science program deals with the social context of science and technology. This area of scholarship is commonly referred to as "STS", which stands for "science-technology-society". It was developed significantly at the post-secondary level during the 1970s, and has been influencing science programs at the secondary and elementary levels since the early 1980s.

This new element has been introduced into all Ontario science courses, at all grades and all levels. For each science topic, the teacher must now include real-world applications of science concepts, and consider societal implications of the related science and technology. At the OAC level, a new course, Science in Society, has been added.

This research project was commissioned by the Ministry of Education to develop an instrument that assesses student attitudes toward science and technology (S&T), and their understanding of certain social issues surrounding S&T.

A number of objectives guided the present study:

- to find a way to obtain a baseline measure of Ontario students' understanding of STS issues (knowledge and attitudes)
- to provide Boards, teachers, Faculties of Education and educational researchers with a tool for monitoring students' understanding of STS issues
- to build on existing research in STS evaluation

The new science curriculum is now being implemented province-wide. It is hoped that the results of this study will provide educators with an effective approach to monitor their progress over the coming years.

2. BACKGROUND

2.1. The New Thrust in Science Education: STS

A number of realities in Canada[1] today have focused the attention of educational and other policy makers on science and technology.

- Science and technology are seen to be key to future economic growth.
- Canada has one of the poorest records in research and development among industrial nations.
- Scientific literacy among the adult population is low.[2]
- Despite a general interest in the results of scientific research, people are not

getting enough information about S&T from the media.[3]
- Fewer students entering post-secondary school are choosing science over other subjects.[4]
- Science enrollments in secondary school are dropping.[5]
- Significantly fewer women than men take science courses in secondary school.
- Canadian student performance in international math and science tests is lower than that of other countries.[6]

These facts have led to widespread efforts to revamp science education, improve public attitudes toward science and technology[7], and provide better advice to policy makers.[8]

The most significant development in the field of science education has been the integration of science-technology-society, or STS, in the teaching of science. The STS movement in education began in the 1970s at the post-secondary level in many industrial countries, notably the U.K., U.S. and Canada. It reached grade schools about a decade later.

Canada was among the first nations to recognize the need for a renewal in elementary and secondary science education that would integrate science and technology into general Canadian culture. The Science Council of Canada initiated a national consultation during the early 1980s[9]. At the same time, individual provinces began to review their science curricula, with the aim of making courses more relevant to the real world. Ontario was one of the first provinces to introduce a new science curriculum with a significant STS component.

The STS focus is particularly appropriate for secondary school science programs, since most students will not go on to specialized careers in science or technology. Yet the influence of science and technology on everyday life is enormous, and growing. Young people must increasingly make personal and professional choices about issues in which science and technology, and scientists and engineers, play a part. Therefore, an essential ingredient in their education must be science, its technological applications and societal implications.

In response to this need, the Ontario Ministry of Education initiated a major renewal of the secondary science program.

2.2. A New Secondary Science Curriculum for Ontario

In 1987, the Ministry of Education introduced a new science program for Grades 7 to 12 and the Ontario Academic Courses (OACs). Twenty-eight new courses were developed to replace science guidelines produced in the 1960s and 1970s. The new secondary science program is described in a fifteen-part set of guidelines that was published throughout the period 1987-89. By September 1989, the new program was fully established, and the implementation phase was in full swing.

The most significant change in the new science program has been the introduction of a strong and unifying STS focus. Now Boards of Education and individual teachers are required to develop and teach for all program levels - basic, general and advanced -

science units which include the practical, concrete and societal aspects of science and technology.

The published aims of the science curriculum strongly reflect the STS philosophy. They focus on the relationship between science and technology themselves, and between S&T and the individual and society (see Table 1).[10]

A primary goal of the new science curriculum is to develop students' scientific literacy. In fact, the policy document makes this point quite emphatically.[11]

"Indeed, the success of a science program might be assessed on the basis of the degree to which scientific literacy is achieved."

In this context, it is important to realize that scientific literacy does not consist of specific content knowledge. In fact, the teaching policy for the new science courses makes a clear distinction between the content of science and the process of science. It warns against overemphasizing the former over the latter, and urges teachers to foster attitudes as well as knowledge and skills.[12] This philosophy is consistent with an integrated STS focus, which presents science as a human endeavour, carried out in a social context.

Table 1
The Aims of the Science Curriculum[13]

1. an understanding of the processes of science
2. skills that are essential for participation in scientific work and technology
3. facility in problem solving through science
4. the basic knowledge needed to function in and contribute to a scientific and technological world
5. respect for the environment and a commitment to the wise use of resources
6. an understanding of the nature of science as a human endeavour
7. an appreciation of technology as the application of scientific knowledge and principles[14]
8. an ability to locate and retrieve scientific information
9. an awareness of the career possibilities in the field of science and technology
10. an awareness of how the knowledge of science enhances personal life management
11. a sensitivity about science and its influence on societal issues and values

The new science curriculum has been designed to develop a larger awareness of science and technology among the total student population. The intent of an STS focus is to make science courses more interesting to all students, and relevant to their lives and personal aspirations. Even students whose interests, abilities and career goals will not lead them to S&T careers, will learn more about science and technology than they did before. Students who want to go on to take university science and engineering will learn to appreciate the larger societal context in which they will study and work, in addition to acquiring the required cognitive skills and knowledge.

However, it will be essential for educators to have a way of assessing the degree to which students respond to the expressed aims of the new curriculum.

2.3. Monitoring Changes in Student Understanding and Attitudes

In order to assess how students are responding to the new curriculum, it is important to be able to track changes in students' understanding of STS issues over time. A way must be found to obtain a baseline "snapshot" of Ontario students' understanding at one time, for a range of grade levels. Comparisons between grade levels for one "snapshot" will reflect differences in level of education and age. Comparisons between "snapshots" taken in different years provides a way to assess changes over time.

The present system of provincial curriculum reviews uses questionnaires developed for specific subject areas. Multiple-choice and/or essay questions are used to assess student comprehension of course material.

For science, banks of questions have been developed that measure content knowledge in some areas of the science curriculum.[15] However, there is now a need for question items that measure familiarity and comprehension of STS-related topics. This project was established to explore the best way to develop such a bank of questions.

2.4. The Present Study

Since the STS mandate is relatively new, there is no base of data against which progress in STS education can be measured. The objective of this project was to develop an instrument that can help provide such information. A very important requirement was the development of an instrument that can be used for Grade 10 and Grade 12 students with a wide range of abilities. This would allow grade comparisons within a given year, as well as tracking populations over time.

2.4.1. Views on Science, Technology and Society (VOSTS)

The starting point for the study was an instrument developed by Professor Glen Aikenhead of the University of Saskatchewan - "Views on Science, Technology and Society" (VOSTS). VOSTS is a bank of multiple-choice items designed over a period of years, in collaboration with graduating high school science students from across Canada. The VOSTS instrument is highly regarded by the international evaluation community, and is one of the only existing instruments for STS at the secondary level.[16]

The research that led to VOSTS began in 1984, and the first published version of the instrument appeared in 1987. The VOSTS question items continue to be developed and expanded, and now cover a wide range of STS topics.

In order to build on this previous research, the terms of reference for the present study were to adapt VOSTS to the Ontario case. A number of specific requirements had to be taken into consideration:

- the final instrument must be suitable for students of grade 10 and grade 12
- the final instrument must be suitable for all levels within each grade - basic, general and advanced[17]
- the final instrument must address the specific STS needs of the Ontario science curriculum

These requirements led ultimately to a radical simplification of the VOSTS structure, and to an expansion of the question format to include a mixture of testing methodologies. As a consequence, the resulting instrument loses some of the subtler analytical capabilities of VOSTS that were appropriate for older, more sophisticated students. However, the instrument has a wider applicability to grade levels and reading and comprehension abilities. In subsequent sections of this report, we will return to this issue, and highlight ways in which the instrument may be used effectively for various purposes.

2.4.2. Project Tasks

A project team was put together consisting of The Impact Group, Market Facts of Canada and Professor Glen Aikenhead in Saskatchewan. Dr. Jeffrey Crelinsten of The Impact was Project Leader. Ms. Jean de Boerr of Market Facts was Senior Consultant. Other members of the project team were Ms. Sheila Kumar and Mr. Ron Ko of Market Facts and Mr. Ron Freedman of The Impact Group.

The project team, in collaboration with the Ministry of Education, established the following sequence of tasks:

1) research the field of STS evaluation

2) correlate VOSTS with the Ontario science curriculum

3) adapt VOSTS to design a single instrument that can measure Grade 10 and 12 Ontario students' understanding and appreciation of the STS perspective.

The goal at the outset was to develop an instrument for grades 10 and 12 students at all levels - basic, general and advanced - for both official languages, for urban and rural populations, and for public and separate schools. The development process proceeded through various phases, which will be described in the Sections 3 and 4. The final instrument was tested with students across the province.

The resulting instrument will be useful for teacher inservice, teacher training and research, as well as for evaluation and monitoring. Another very interesting project would be to use the instrument for a province-wide survey. This would generate the first baseline of information on Ontario students' knowledge and attitudes in the STS area. Subsequent province-wide surveys could be taken with the same instrument, and comparisons could help assess progress in STS teaching in Ontario over time.

2.4.3. The Choice of the Target Group - Grades 10 and 12

The VOSTS questionnaire was designed for graduating high school students, and tested nationally. Even though students were involved in the design of the questions, the reading level required to understand a typical VOSTS item is rather high. Therefore, the Ministry decided at the outset to adapt VOSTS for Grades 10 and 12 as an initial step. The strategy selected was to try to design a single instrument for all levels of students within the two grades (basic, general, advanced), and to test the instrument in schools.

Grades 10 and 12 represent graduates of Grades 9 and 11 respectively. The Grade 9 cohort is important because its members provide a "control" for the analysis. It would have been ideal to use grade 6 graduates (grade 7 students) as a control group, since they represent the "entry level" into the new intermediate and senior science curriculum. However, it was felt that the VOSTS questionnaire would not be easily adapted to this age group, and at the same time be useful at senior secondary grades. Therefore it was decided to use grade 10 students (grade 9 graduates) as the "entry" level group, and to adapt the VOSTS questionnaire to this age group.

Ideally, OAC students (grade 12 graduates) would be used as the experimental group, since the original VOSTS instrument was designed with these students' input. However, large numbers of students do not proceed to OAC. The grade 12 student cohort represents the best compromise between STS exposure and experimental practicalities. Grade 12 students (11th grade graduates) will have had two more years of an integrated STS focus in science instruction than the grade 10 (grade 9 graduates) group. The grade 9-11 range is also appropriate since these years were ones, at the time the data were gathered, in which the basic, general and advanced streams applied. This allowed meaningful comparisons among the three sub-groups, using the modified VOSTS instrument.[18]

3. METHODOLOGY

3.1. A Survey of the STS Evaluation Literature

The international STS evaluation literature was researched as a preliminary step to the study, and a literature review was prepared (see Part Two).

It was found that the use of STS in science teaching at the secondary level is growing rapidly in most developed countries and many developing countries. However, there is an extreme diversity of views among educators and policy makers around the world regarding why STS education is important, and exactly what constitutes good STS education. For example, in the U.S., the primary reason for initiating STS programs was a fear of losing S&T dominance to the Soviet Union, and later Japan. In the U.K., social activism and a rebellion against specialization in the school system have been identified as starting the STS movement in British schools. In developing countries, STS is an integral component of the development process.

When it comes to what STS education is all about, opinions differ as widely. Some science educators see science content as primary, and STS in a supportive motivational role. Others see STS as empowering students to take critical social action, by developing critical thinking and social skills. Often there is conflict between various views held by different practitioners. The literature indicated a need to involve teachers in the process of STS curriculum development, and to provide support materials and inservicing. There is evidence that while most science teachers support STS, many feel unqualified to teach it properly.

Specific evaluation techniques used include multiple-choice questions, Likert-type (bipolar) instruments, essay instruments and interview instruments. The most common are the multiple-choice and Likert-type since the processing of the data is much easier. However, there are limitations to these techniques. Multiple-choice questions are often designed with certain assumptions, and the interpretation of the results is accordingly suspect. Likert-type measures of student attitudes toward STS issues are problematic, because the design of these measures is uni-dimensional. They measure attitudes on a single continuum from "strongly agree" to "strongly disagree". STS issues, however, are often multi-dimensional in nature. It is therefore necessary to have controls and cross-checks to interpret the results of such tests properly.

In developing VOSTS, Aikenhead used Likert-type scales, essays and interviews to derive empirically a series of multiple-choice items dealing with STS issues. The resulting instrument, Views on Science, Technology and Society (VOSTS) is a multiple-choice instrument that measures students' knowledge (reasoned beliefs) about STS issues. Aikenhead has compared results obtained using VOSTS with those obtained using only Likert-type, essay or interview instruments. He found that the empirically-derived multiple-choice items in VOSTS provided significantly less ambiguous results than did the Likert and essay techniques. The interviews provided the most accurate data, but took the most time, and hence resources. VOSTS offered the most efficient of all modes.

A number of specific issues have been investigated by the international STS evaluation community. These include gender, cultural differences, views about science and technology, and regional differences. Good instrument design for monitoring and evaluation purposes must attempt to be:

- gender neutral
- sensitive to cultural diversity
- inclusive of various views regarding the nature and importance of science and technology
- locally relevant wherever possible

3.2. Monitoring versus Evaluation

The diversity of views about STS itself makes evaluation difficult. Interpreters of data from any one instrument must bear in mind the variations that exist in the STS field itself, as well as the teaching and learning environments in which it is taught and learned.

The best strategy for a useful instrument is to use it to establish a baseline of views from which to monitor progressive change. In this way, even an incomplete scan of students' understanding and appreciation of STS issues can be an effective tool for monitoring change.

For this reason, the project team and its advisors decided to shift the initial emphasis on evaluation to one on monitoring. The latter term is more appropriate when thinking about how to assess progress in the STS aspects of Ontario's science curriculum. Since the STS field itself is diverse and subject to varied interpretations, it would be counter-productive to develop an instrument that purports to evaluate students' knowledge in the STS field. Rather, the instrument should attempt to provide teachers with a tool they can use to monitor change over time.

This point emerged strongly in discussions with teachers during the design phase. Many teachers felt that STS is a new aspect of the science curriculum, and that they need tools to help them develop and refine their teaching. This includes familiarization with relevant and interesting issues, and with standard STS vocabulary.

The vocabulary issue is particularly relevant. STS falls into the domain of the social sciences and humanities, where reading comprehension is an integral part of the learning process. Students' in Ontario schools have a wide range of reading ability. An instrument that is practical for a wide range of reading ability will be more useful to monitor progress in STS learning over time, rather than evaluating students' knowledge.

The decision to develop a monitoring instrument evolved over the early stages of the project. This evolution is described in more detail in the following section.

3.3. The Starting Point - VOSTS

The starting point for this study was the instrument developed for graduating high school science students - Views on Science, Technology and Society (VOSTS). This instrument[19] was adapted through a detailed consultative process described in Section 4 of this report. This section elaborates some of the features of VOSTS as a tool for measuring students' understanding of STS issues.

It is important to point out that VOSTS measures knowledge rather than attitudes. The STS topics included in VOSTS are limited to those emphasizing student thinking rather than student attitude. Attention is not given to feelings about global or regional issues. Instead, VOSTS focuses on the reasons that the students give to justify a viewpoint. Consequently VOSTS consists mainly of information viewpoints; that is, cognitive beliefs.

The beliefs addressed by VOSTS items are limited to a domain of topic which has been described[20] as the "social aspects of science," in contrast to "social issues" themselves. That is, VOSTS does not elicit student reaction to social issues such as pollution, but VOSTS does monitor students' reasoned beliefs about how science and technology contribute to such problems, and how science and technology may help resolve them.

VOSTS content is, in part, based on the same theoretical models which validated the standardized instruments developed in earlier years of STS evaluation.[21] VOSTS content is also based, however, on the more recent literature concerning the social and technological aspects of science.[22]

The topics in VOSTS are grouped within the following categories:

- Definitions of science, technology and R&D
- The influence of society on science/technology
- The influence of science/technology on society
- The influence of school science on society
- Personal characteristics of scientists
- The social construction of scientific knowledge
- The social construction of technological knowledge
- The nature of scientific knowledge.

Each VOSTS item is assigned a five-digit code. For example, consider item 90521 (see Appendix C).

- The first digit (9) corresponds to section nine ("the nature of scientific knowledge").
- The next two digits (05) refer to the topic number within that major section ("hypotheses, theories, and laws").
- The fourth digit (2) indicated the item number within that topic. For instance, 90521 is the second item for topic 05 in section 9.
- Lastly, the fifth digit differentiates items which have slight but significant variations in their wording, such as a different example or a different key word. Thus, item 90522 would have a small but significant change in its wording from item 90521. Only a few VOSTS items exhibit this slight variation.

Teaching science through STS means that STS content is taught in conjunction with the normal science discipline content of facts, principles, concepts and problem-solving skills. Thus, VOSTS by itself does not assess an STS course. VOSTS assesses some of the STS objectives or goals of an STS course.

Other limitations to VOSTS should be noted:

VOSTS is only one strategy for monitoring students' reasoned beliefs about STS topics; namely, a multiple-choice instrument. Other methods include essay writing, oral examinations, reports, projects, and check lists. By deleting the multiple-choice options from a VOSTS item, a teacher can transform a VOSTS item into an essay type exam question, and accurately assess students' viewpoints on an STS topic by reading their paragraph responses to the VOSTS statement. This assessment, of course, depends on a teacher having (1) discussed the STS idea in class, (2) acquainted students with writing paragraphs in science class, and (3) the time to read and grade the paragraphs. A three-point scoring system usually works well: three points for an answer which is complete and to the level of sophistication one expects; two points for an answer falling a bit short of expectations; one point for at least writing something accurate on the topic (demonstrating that the classroom material was being applied); and zero points for answers off topic or expressing misconceptions or naive conceptions on the topic.

Unlike the typical multiple-choice question, VOSTS items have no absolutely "right" answers among the choices. One must examine the choices ahead of time and decide which choices students should pick if students have attained the objectives of a curriculum. In some cases, there may even be more than one acceptable choice. Also, one needs to identify which choices are incorrect, naive or inappropriate. Students selecting these are indicating that they have not attained the curriculum's objectives.

Current thinking in the STS literature will identify certain perspectives as being the most accurate portrayals of science in a technological and social context. These perspectives will, one hopes, be embraced by a science curriculum. Therefore, in terms of specific perspectives on STS, VOSTS items do have "right" answers. However, arguments by informed scholars over what qualification ought to be attached to those "right" answers form the basis of more sophisticated and elaborate VOSTS choices. We will return to this issue when discussing the final instrument developed in the present study (Volume 2).

The VOSTS item pool is a new tool for monitoring students' reasoned beliefs about STS issues and for initiating class discussions. Because the choices for each item were derived empirically from students' views on STS topics (rather than from science educators' philosophical positions), a teacher can feel secure in knowing that the meaning which teachers read into each choice is likely the same meaning which students read into each choice.

A teacher can select those VOSTS items which suit the teacher's particular instruction. Although the 114 VOSTS items cover the domain of STS topics pertaining to reasoned beliefs, the item pool does not address all possible STS topics. Consequently, teachers can modify or develop their own items and add them to their personally selected pool of VOSTS items.

3.4. Using VOSTS to Fulfill Project Objectives

The very complexity and sophistication that makes VOSTS an exciting and useful instrument for STS evaluation at the graduating high school level, makes it unsuitable for an instrument to monitor students' STS knowledge and attitudes at lower grades. Nonetheless, the content of the VOSTS items served to be an excellent starting point for developing a monitoring instrument for Ontario schools.

The powerful feature of a VOSTS item is the wide range of options listed for the student to choose from. Through careful consultations and testing with students, the VOSTS items have been refined to include a wide, and subtle, range of possible interpretations of each issue. These diverse and detailed interpretations are held by students themselves, and expressed in their own words.

While this detail is an asset, it was also a liability in the context of project objectives. A student must read - and understand - a large amount of text for each item. This limits the number of items that can be administered in a typical testing situation. More serious, however, is the fact that students with limited reading comprehension and interest are handicapped by the amount of reading required to answer even one question.

The goal of this study was to produce an instrument that could be handled with the entire range of abilities between basic grade 10 and advanced grade 12. This requirement made it impossible to use the VOSTS instrument as is. In particular, the reading level had to be simplified, and the number of options reduced. The total number of items was also reduced, as described below in Section 4.

In addition to simplifying the existing VOSTS structure, the project team included a variety of other elements into the instrument design. During the design phase (see section 4.1 below) a combination of multiple-choice, essay and interview techniques was used. VOSTS items were selected, revised, and tested with teachers and students. An open-ended essay question was included for each item. And finally, for comparison, a battery of bipolar attitudinal statements was designed independently from the VOSTS items, dealing primarily with attitudes toward science, technology, and STS-related issues.

Focus groups were held to discuss teacher and student reactions to the various items. In the final analysis, it was decided to develop an instrument that included simplified VOSTS-type items plus the battery of bipolar (Likert-type) attitudinal statements. The reasons for this decision will be elaborated in Section 4.

4. DESIGN AND TEST PROCEDURES

4.1. Summary of the Design Process

The starting point for the design was the VOSTS instrument, consisting of over 100 items relating to various aspects of STS. The challenge lay in the requirement to provide one instrument for both grades 10 and 12, and all three levels (basic, general, advanced) within each grade. Since the reading ability among these different groups varies radically, we had to design as simple a questionnaire as possible, while incorporating as many as possible of the sophisticated STS concepts developed in VOSTS.

The design process was divided into four phases:

1) Initial consultation and design of English draft version
2) Focus testing and revision
3) Pilot test of revised English version
4) Revision, translation into French, and final test in both official languages

These four phases are described separately in the following sections.

4.2. Initial Consultation and Design

A small Advisory Group of science consultants and teachers was recruited for the initial consultations.[24] The group was asked to examine the original VOSTS items, and advise the project team on whether or not the items were appropriate for the target group of Grades 10 and 12 students. The unanimous conclusion was that the items could not be used as is, and would have to be simplified. Some felt that only the advanced level grade 12 students would be able to handle the VOSTS items. All agreed that Grade 10 students could not be expected to deal with them.

It was also recognized by everyone - client, project team and educational advisors - that some of the issues covered in VOSTS are of marginal interest to grade 10 students. Nonetheless, it was agreed that we should try to design a preliminary instrument that built on these issues, since the VOSTS instrument has already generated a national database at the grade 12/OAC level with which we could compare results. It was also recognized, however, that our initial goal might not be achievable.

The VOSTS instrument contains over 100 separate items. It was decided to select about one quarter of these items, focusing on topics that most directly relate to the aims of the Ontario science curriculum.[25] A detailed comparison revealed that the VOSTS areas 2 and 8 are not covered by the Ontario aims, which focus more on the nature of science and technology and their effect on the individual and society. The social construction of scientific ideas and processes, and the nature of the scientific community, are important domains in STS, but are not covered in the aims.

A meeting between the Project Team, Ministry officials and the Advisory Group was held to finalize the selection of VOSTS items that would be adapted. Table 2 indicates the VOSTS item numbers that were selected.

The next step was to adapt these items to a form that would be easier to read. Exhibit 1 shows an early design for item 40211, that was ultimately rejected (see Appendix B). It is instructive, however, because it clearly illustrates a key design issue. A typical VOSTS item presents a list of responses, in a specific order, usually from agreement down to disagreement (sometimes the order is reversed). There is a good possibility that students with poor reading ability will tend not to read all the options before choosing.

To address this concern, the left-hand column in Exhibit 1 (see Appendix B) was designed to tell the student quickly that the options are listed in a specific order running from agreement with the initial statement, to disagreement. Then they would only have to read the detailed options relevant to their initial reaction in favour of or against the initial statement.

Table 2
VOSTS Item Numbers Selected for Adaptation

10111 10211 10411 10421	40211 40311 40412 40421 40451 40511	50211 50313	60111 60221 60511 60611	70121 70221 70711	80131	90211 90411 90621 90641 90651 90711 90811

While this design was ultimately rejected, it incorporated some important features, which were retained in the preliminary test version. Students completing VOSTS items are instructed to read the top statement and think whether or not they agree with it. Then they must read all the options carefully, and select the one that most closely fits their opinion. The design in Exhibit 1 makes the initial reaction explicit, and asks the student to select an option. Then they must decide, using the more detailed descriptions, on how to fine tune their response. This feature appears in a different way in the preliminary test version. (However, by the final version the opening statement had been eliminated.)

An "I don't care" option was added, to see if it elicited significant responses, compared with the "I don't know" response. The open-ended question at the end allows students to explain what they mean, or why they don't understand, or add a nuance or option that was not covered. Both features were retained in the preliminary test version, and only the open-ended question survived in the final instrument.

The form ultimately selected for preliminary testing is displayed in Exhibit 2, next to the original VOSTS format (see Appendix B). There are several features to note:

- the initial statement is presented clearly, in large capital letters, in a box
- the first question allows students to record their immediate reaction to the

statement, including whether or not they even care about the subject

- the second question presents options, adapted from the original VOSTS item
- the options are not necessarily ordered sequentially as in the VOSTS items
- the language is simplified
- the third open-ended question allows students to write in a response in their own words

In addition to adapting a selection of VOSTS items as described above, a battery of bipolar statements was drafted. These statements were designed to measure attitudes toward science, technology and STS-related issues. They were not designed to measure students' comprehension of STS issues, only what they feel about them. There were several reasons for including this component in the preliminary instrument:

- it allows attitudes to be measured, in addition to cognitive beliefs
- it was desirable to compare this simpler format with the more complex format of the adapted VOSTS items
- the bipolar statements could cover issues that the longer VOSTS adaptations could not

The preliminary instrument that emerged from this design phase consisted of two elements:

1) Twenty-six "knowledge" statements, adapted from VOSTS items
2) Thirty-seven "attitudinal" statements

4.3. Focus Testing

The preliminary instrument was tested separately with teachers and with students. Both sessions were conducted at the offices of Market Facts of Canada, 77 Bloor St. West, Toronto. Focus groups were conducted by Ms. Jean de Boerr of Market Facts. Project Team members and Ministry officials observed from behind a one-way mirror. The subjects were told at the beginning that they were being observed.

Teachers

The session was held from 6:00 p.m. to 9:00 p.m., Wednesday, 20 September 1989. 11 teachers were recruited from the Toronto area. A cross section of disciplines and program levels (basic, general, advanced) was represented.

The teachers were give the first part of the instrument, consisting of the adapted VOSTS statements, and asked to fill in the questionnaire. They were then given the bipolars to fill in.

A discussion of the two parts of the instrument was led by Ms. Jean de Boerr of Market Facts. The rest of the Project Team were behind the one-way-glass. After an hour of discussion, they came into the room to continue the discussion with the teachers.

Students

The session was held from 5:00 p.m. to 8:00 p.m., Thursday, 21 September 1989. Students were recruited from schools in the Metro Toronto area. The breakdown of grade, level and gender are given in Table 3.

Table 3
Student Focus Group
Grades, Levels and Gender

	Grade 10			Grade 12			OAC
	B	G	A	B	G	A	
Female	6	1	1		1	1	1
Male			2			1	

Each student was given four of the adapted VOSTS items, and all of the attitudinal statements. This ensured that students had adequate time to fill in their own questionnaire. Each of the adapted VOSTS items had two or more students filling it out.

4.4. Summary of Main Findings of Focus Groups

4.4.1. Teachers

The teachers who participated in the focus group had a great deal to say about the instrument. Even those who were teaching at the advanced level felt that the multiple choice items were too complex. Those teaching grade 10, or at either grade at the basic or general level, felt that their students would not understand most of the statements. One teacher expressed concern, because about 25% of this teacher's students were also studying English as a second language.

Not only was reading level a concern, but also level of interest. Many of the teachers in the focus group warned that the issues covered in VOSTS are not of interest to grade 10 students, especially students in basic and general level programs. They felt that the younger students would simply not be interested in many of the items. This was borne out during our student focus group, which included several students from the grade 10 basic program. They were simply not interested in, or could not comprehend, many of the statements.

When it came to the bipolar statements, most teachers felt that they would be understood and accepted by their students. They recommended that even if the multiple choice (or some simplified version) was used, the bipolars should remain in the instrument.

The teachers' response to the overall exercise was quite interesting. Some were skeptical about the STS approach, and were not happy about being judged on their abilities to teach a subject that they did not think appropriate for science class. Even among those who supported the STS approach, many teachers felt inadequate about teaching it since they were not trained in the area themselves. Another fear expressed by some was that the addition of STS topics would overload their teaching responsibilities. "We have more than enough to do to cover the required science content, let alone STS", remarked one teacher.

However, most teachers praised the Ministry for commissioning the present study to design an instrument for monitoring students' attitudes and understanding of STS issues. Some teachers urged that the instrument, whatever it turns out to be, should be used for teacher inservice, and by teachers in the classroom to explore STS issues with their students. This point was also made quite emphatically by several members of the Advisory Board.

In summary, teachers recommended against using the multiple-choice items as presented. They recommended radical simplification if we wanted to administer the questionnaire to the younger students, and to those with lower reading abilities. They also recommended keeping the bipolar items.

4.4.2. Students

A number of students in grade 10 basic level participated in this group. In the early part of the discussion, these students (most of whom were female) were noticeably reticent to discuss the instrument. As the discussion progressed, they admitted that they were not very interested in many of the statements. In contrast, some of the older students, even a few at general level, were more open to discuss some of the topics. In general, the assessment of the multiple-choice items was that they were too difficult.

The open-ended question on the multiple-choice items proved to be very useful in this regard. Many of the students took the time to fill in the box at the end of the multiple choice items. In a number of cases, the student wrote that they did not understand the item, yet they circled options (other than "I don't know") for both questions 1 and 2. This highlighted the need for precision and careful design. To these students, clearly "I don't know" was not synonymous with "I don't understand".

When it came to the bipolar items, the students responded much more favourably. They all took the time to answer them (whereas some of the students in grade 10 basic level did not answer their multiple-choices). During the discussion, they recommended that the bipolar statements be included, because they were interesting to fill out, and easy to understand.

4.4.3. Revisions

Based on the discussions and the feedback from the teachers and students, as well as further consultations with the Advisory Group, major revisions were made to the adapted VOSTS items. The initial statement was dropped, as well as the initial question asking students to respond to the opening statement. Each item was edited down to three or four choices. The result was a more conventional, much simpler, multiple-choice questionnaire.

The main advantage of the change was the reduction of the amount of reading. Instead of having one item per page, several items could be placed on one page. This reduced the size of the questionnaire, making it less intimidating. The main disadvantage, of course, is the loss of the subtler shades of meaning which characterize a VOSTS item. However, all those involved in the project agreed that the resulting instrument would allow comparisons to be made between levels within one grade, and between grades 10 and 12.

The open-ended question at the end of each multiple-choice item was retained for the pilot test. The bipolars were kept as well.

There is a total of 38 multiple choice items, presented six on a page, and 44 bipolar statements. The instrument was pilot tested province-wide in both urban and rural areas, in the English language.

4.5. Pilot Test

The pilot test had a number of specific objectives:

- to gain insight into the level of acceptance by authorities at various levels
- to test the degree of ease with which students in urban and rural settings would be able to answer the questionnaire
- to test the appropriateness of the language level of the questionnaire for grade 10 students
- to test the comprehension and coverage of the multiple-choice statements
- to solicit open-ended responses (in order to test comprehension and adequacy of coverage of issues in the multiple-choice statements)
- to test the attitudinal statements
- to test one OAC class in order to provide a comparison with the same level of sophistication used to develop the original VOSTS items

During the test setup we continued to encounter problems with the grade 10 population, and the basic grade 12. As described below, we could not get approval to test students in basic level programs at either grade, nor students in general level programs in grade 12. Nonetheless, we tested all other subgroups, and were able to generate useful data.

4.5.1. Setup Procedures

Since this test required in-class time of students, we obtained permission both from the Board of Education and the school principal.

In addition, a letter was drafted for signature by the principal, to ensure that appropriate consent forms had been collected. This procedure was adopted to satisfy the requirements of the Freedom of Information and Protection of Privacy Act.

4.5.2. Site Selection

The questionnaire was made slightly longer than the final version would be, in order to cover as much content as possible and to provide some redundancy.[27] As a consequence, the test could be administered only in class periods of more than one hour duration. For this reason, site selection was limited to schools that had at least one class period of 75 minutes, or two consecutive science periods on any one day of the week. This requirement limited the number of sites that were eligible for the test.

In order to select appropriate sites, we first had to determine the overall distribution of secondary schools in Ontario. In particular, we needed to know the representation of the various sub-populations that needed to be studied (basic, general, advanced, urban, rural, public, separate), in order to ensure that we did not use too many schools with sub-populations that are rare.[28] When selecting sites for the final test, we would not be able to choose ones used for the pilot test. So it was essential to determine whether or not any of the sub-populations were under-represented.

There is a total of about 600 English language Ontario schools (public and separate) that offer science courses at both grades 10 and 12. Using this as the total school population, we then determined the breakdown according to levels within each grade. We restricted the population to schools whose class sizes are 20 students or more (numbering about 560 in total).

Table 4
Number of schools offering science courses with 20 or more students

Grade 10	Basic	<80
	General	>450
	Advanced	>450
Grade 12	Basic	<20
	General	<250
	Advanced	>450

Table 4 indicates that grade 12 basic level science programs represent a small percentage of the total number of students enrolled in the subject, and that even in grade 10 programs, the number of basic level science courses offered is low, relative to the other two levels. Furthermore, in grade 12 the general level is considerably smaller than the advanced.

In light of these findings, the sample selection for the preliminary test was modified slightly. It was decided to try to test all three levels (basic, general, advanced) in grade 10, but not in grade 12. This would allow the widest possible test of reading level at grade 10, while saving the few schools offering Basic Grade 12 Science for the final test.

As for students in Basic Grade 10 programs, prospective sites were selected and informal inquiries were made. In two cases - one small rural board and one large urban board - initial indications at the school level were positive, but later formal requests at the Board level were denied. In the rural case, there was interest in participating in the final test, but not the preliminary one. At the urban Board, it was felt that the questionnaire was too complex for students in Basic Grade 10 programs.

Given the urban Board's reaction regarding the inappropriateness of the questionnaire for students in Basic Grade 10 programs, it was decided not to continue searching for basic classes for the preliminary test. Since the population of basic level programs relative to the others is so low, it was felt that basic programs should be saved for the final test. Table 5 gives a breakdown of the pilot test sites and the student populations at each site. The top row is a rural school. All the rest of the sites are in urban locales.

Table 5
Test Sites and Sub-Populations
(Total Population Size: 215)

Site Location	Grade 10 Classes			Grade 12 Classes			OAC
	Basic	General	Advanced	Basic	General	Advanced	
Dundas		19	23			15	38
Ottawa		31	22			18	
North York		18	20			11	
TOTAL		**68**	**65**			**44**	**38**

The total student population tested was 215 students, which is a very large sample for any pilot test. The results were useful for comparing general and advanced within grade 10, and advanced grade 10, advanced grade 12 and OAC.[29]

4.6. Summary of Main Findings of Pilot Test

When we compared the percentages of write-ins for the first half of the questions with the percentage for the second half, it was obvious that the numbers of students writing in their own comments dropped dramatically. This drop can be attributed to a fatigue factor. Clearly students were becoming tired or losing interest long before the end. This possibility was predicted by several of the school authorities who were asked to approve testing. In fact, some did not want to subject their students to such a lengthy questionnaire.

This problem was dealt with in the next round of testing, by cutting the total number of multiple-choice questions in half. Each set of students was given only one half to answer. Within each half, two sets were prepared in reverse order, so that when the scores were totalled, any remaining fatigue factor could be averaged out.

Question #38 received an anomalously high percentage of write-ins. When these were read, we found that students were reacting very strongly against the notion of having to take more courses, whatever they might be. Comments of the sort "students should decide themselves what they want to take" were the rule. This evidence indicated that the question was inappropriate, and it was dropped.

Analysis of the write-ins, and of the percentage responses, allowed the project team to weed out some spurious items, and to improve others. Table 6 gives a summary of the changes made to the multiple-choice items, based upon the pilot test.

The total number of multiple-choice items in the final instrument dropped to 29.

In addition to these changes, a number of the bipolars were edited, and several new ones were added. The total number of bipolars in the final instrument went up to 49.

Table 6

Multiple-choice #	Change	Reason
2	edited	removed bias
	option added	improved range
3	discarded	one option swamped (92%)
4	converted to bipolar	more appropriate measure
10	edited	improved clarity
12	discarded	problematic, swamped (84%)
22	edited	improved clarity
26	discarded	swamped (83%)
28	edited	simplified
32	discarded	problematic, simplistic
33	edited	improved clarity
34	edited	(steps of the) scientific method
35	discarded	swamped (80%)
36	discarded	problematic, simplistic
37	discarded	problematic
38	discarded	problematic

4.7. The Issue of Student Reading Level

Throughout this project, the issue of student reading level was a major concern. During the setup phase for the pilot test, as noted above, several officials refused to subject their students to such a long questionnaire. Furthermore, as the focus groups indicated earlier, the comprehension level of many grade 10 students is much lower than that of their counterparts in grade 12. What might be acceptable for grade 12, might not be useful for grade 10.

Nonetheless, the pilot test indicated that students were generally able to deal with the material presented to them. A random analysis of the write-ins showed that even grade 10 students were able to comment on the issues, albeit at a simpler level than that of the older students.

While the sophistication of the original VOSTS instrument has been eliminated, the topics covered are the same. For purposes of comparing grades and other subgroups, the resulting instrument will be able to provide extremely useful information. If used for teaching purposes, teacher inservice and teacher training, the instrument can improve STS education over time. Variations in reading level among students can be accommodated by teachers administering the questionnaire.[39]

A major test of the instrument was carried out across the province, in both official languages. As described below, the instruments were broken into smaller sections. In this way, no one student had to read more than half of the entire "bank" of items. This technique assuaged the fears of those officials who had refused to participate in the pilot test. The revisions, and the technique of splitting both parts of the questionnaire, sufficed to ensure them that the students would be able to handle the assignment.

The final instrument appears in Appendix A. This version, in both official languages, was used to conduct a final province-wide test.

4.8. The Final Test

4.8.1. The Questionnaire

The "bank" of multiple choice questions and attitudinals (bipolar items) to be included in the final stage of the study equalled twenty-nine and forty-nine respectively. The desirability of incorporating them into the framework of a single, all encompassing questionnaire had to be weighed against the following considerations:

- The time taken to administer a draft version of such a unified questionnaire during the pilot study was in excess of one hour. The average class period in most schools (barring the semestered ones) is, on the other hand, limited to a 45 minute duration. This necessitated that the questionnaire length be shortened to allow for a response time of not more than 35 minutes (the remaining 10 minutes being required for other related preliminaries and post-completion procedures).
- At the time of the pilot study, some school teachers and Board officials expressed reservations about the questionnaire length especially in the context of students in Grade 10 Basic level programs.
- The pilot study indicated that - most probably due to respondent fatigue or boredom - the quality and quantity of responses began deteriorating somewhat

along the length of the instrument, especially in the latter half.

- The targeted sample size i.e. 1,500 students was large enough, that halving the effective sample base by dividing the "question bank" into two independent sets would still produce completed questionnaires in the subgroups, large enough for independent examination.

With these considerations in mind, two versions of the final test instrument were developed, each having 15-16 multiple choice items and 24-25 bipolar attitudinals. The twin instruments thereby arrived at, were ones that could be accommodated within a 45 minute class period; were not of a length likely to diminish their suitability for certain grades/levels (especially grade 10 Basic); and, finally, would not induce respondent fatigue due to excessive length.

Multiple choice items came first in both versions followed by the attitudinal bipolars. The knowledge statements "Science is ..." and "Technology is ..." were common to both versions as was their position as the "opening" questions.

The distribution of individual question items between these two **independent** versions of the instrument - which let us refer to as V1 and V2 - was done in a way that ensured an equivalent division not only of numbers but of subject matter as well. Careful intra-version sequencing of items addressed the concern that responses to any one of them may bias some of the other responses.

A final precaution was taken to immunize each of the component multiple choice or bipolar items of the two instrument versions from order bias arising as a result of their sequential position within the instrument. V1 and V2 were each administered in two forms, in which the item content remained the same, but their positioning was reversed (except for the knowledge statements "Science is ..." and "Technology is ..."; the earlier described position of these two items was unchanged.) The four versions of the instrument thereby developed were translated into French for the francophone students.

4.8.2. The Sample

1. **The sample size** in total comprised 1,422 students. Each student in the sample provided responses to one basic version of the instrument i.e. V1 or V2, the sample size for each of these versions being 717 and 705 respectively. Only 24 'completed' questionnaires (or 1.7% of the total) could not be included in the sample because of the poor quality of responses.

2. **The sample profile** in terms of Grade 10 and Grade 12 science students was as follows:

Version 1	Grade 10 science:	386 respondents
	Grade 12 science:	331 respondents
Version 2:	Grade 10 science:	384 respondents
	Grade 12 science:	321 respondents

3. **Sample selection** was done in a three stage process.

i) The primary sampling units were secondary schools in the province, having Grade 10 and 12 science classes, drawn from a list provided by the client.

ii) In each selected participating school, specific Grade 10 and Grade 12 science classes were chosen.

iii) All students in these classes, who had the necessary consent to take part in the survey and who were present on the day the questionnaire was being administered, were included in the sample. (Consent forms were required to be signed by the parents of students below 18 years of age. Those students who were 18 years or older could sign these forms themselves.)

The rationale underlying the choice of the target group (i.e. Grade 10 and 12 science students) has already been specified. Other considerations taken into account at each stage of the sampling process were as follows:

a) Selection of schools

- A Grade 10/Grade 12 matched sample, from the **same** science course level (Basic, General or Advanced) was to be drawn from each school, thereby preventing the effect of inter school differences on grade/level comparisons.

  The sampling frame (of schools) was therefore restricted to those schools having **both** Grade 10 and Grade 12 science classes with the same science course level (Basic, General or Advanced) being offered at both grades.

- School data provided by the client revealed that the number of students in any one school/grade/science level varied from as few as **two to over four hundred**. In most schools, again, student populations - and class sizes - were higher in Grade 10 than in Grade 12. Only those schools listed as having at least 20 students in each of the target grades/levels were included in the sampling frame. This was done to ensure a reasonable student "yield" per sample school; as equitable a distribution as possible of the student samples among selected schools and finally, uniformity in the representation of Grade 10 and Grade 12 students.

- Apart from Grade and science course level, data were also to be analyzed by:

  - Urban/rural students
  - Public and separate students
  - Anglophones and francophones
  - Central and other regions

  The selection of schools was done to facilitate such analyses.

- It was expected that from each selected school, the student sample -inclusive of both

Grades - would be 30. To ensure the required total student sample of 1,500 an initial draw of 54 schools was made.

b) Selection of classes

The selection of specific classes (within a grade/level) in the participating schools was done primarily with a view to ensuring as close a numerical match as possible between Grade 10 and 12 student samples within a school, and in turn equivalence in the Grades 10 and 12 subsamples overall.

In schools having more than one science course level in the two relevant grades, required subsamples at the different levels was a further consideration taken into account at this stage.

c) Selection of students

Once the school and specific classes were selected, no further screening of the students themselves took place. Rather, as mentioned above, all consenting students who were present on the day the study was administered, were included in the sample.

4. Selection procedure

a) The starting point was the list of secondary schools having both Grade 10 and 12 science classes, provided by the Ministry. Of these, the "qualifying" ones made up the sampling frame, from which were excluded the three pilot-test site schools (see Exhibits 3 and 4 in Appendix B).

b) Independent samples of English and French schools were drawn. Since they were listed by region and within region by public and separate units, a random selection ensured proportionate representation for the two samples, as well as for population density sub-cells within the two language groups.

c) The draw of schools at this initial stage of the sampling process, equalled fifty-four (see Exhibit 5 in Appendix B). At an estimated yield of over 30 students per school, this number was in excess of estimated requirements, having made allowance for attrition. This was just as well, for attrition due to various reasons did, as expected, erode into the number of such primary sampling units (schools) from which the final student sample could be selected.

Some of the causes of attrition were:

- Some Boards of Education declined to participate, some did not receive official, written authorization from the Ministry in time and would not proceed without; some were unable to give the "green signal" on time because of survey authorization procedures e.g. screening by a Research Review Committee which sometimes was not scheduled to meet until two months after the initial contact was established, and some Boards had other research priorities at the selected schools.

- At the school level also, some declined to participate due to other survey commitments; an inability to accommodate the STS study during the scheduled in-field time period; other commitments such as tests or examinations, and finally, smaller student numbers than those in the initial sampling frame information.

- A further disqualification factor was the classification of chemistry as a Grade 11 credit and that of physics as a Grade 12 credit. Due to internal scheduling, Grade 12 students in one school were taking the chemistry course and those in Grade 11 were taking physics. Which of them would qualify as a Grade 12 science student? Rather than attempting to answer the question, this school was excluded altogether from the sample.

d) As for the "consenting" schools, four of the eleven French schools able to participate in the study, had switched from public to separate school boards within the last year. This adjustment has been made in all Exhibit tables. The number of other such shifts that may have taken place is however not known. The public vs. separate distribution of French schools as shown in Exhibit 3 may not therefore entirely reflect the currently prevailing patterns.

e) On establishing contact with the selected schools, it was also revealed that: i) the actual number of students available in each school differed - substantially in some cases - from initial estimates; ii) as mentioned above, there was substantial inter-school variation in class sizes as well. Logistical and administrative reasons precluded the inclusion of "fractions" of a class. Student sample availability in each school was therefore also a function of class sizes amongst other factors.

f) In all, in excess of 2,000 questionnaires were dispatched to a total of 37 schools, which it was felt would ensure an end sample of well over 1,500 completed questionnaires even after accounting for absenteeism, lack of the required consents, and non participation for any other reasons . The completed questionnaires from one school were received too late for inclusion in the sample. Data regarding this school have been omitted from Exhibits 6 and 7. Exhibit 8 shows the final students samples obtained, based on returned questionnaires.

4.8.3. Fieldwork Organization and Logistics

Organizationally, the field work stage of the study required intensive interaction and coordination with Board of Education and school personnel. The response and degree of cooperation received at both Board and school levels was positive.

The activity flow from sample design to receipt of completed questionnaires from participating schools, is given below.

1. The first step was to obtain the consent of the relevant Boards of Education, done prior to attempting to establish contact with the sample schools. This began during the third week of January, 1990.

2. Board personnel were contacted by telephone, followed by a letter applying for the required permission. The procedural aspects for obtaining this varied from one Board to another and ranged from immediately giving the go-ahead over the telephone itself, to requiring that special submissions for review by committee be made. All such specifications were complied with.

3. The next step involved establishing contact with the school principals - again done both by telephone and by letter. This stage was initiated during the last week of January, 1990. In those schools that agreed to participate, specific Grade 10 and 12 classes to be included were arrived at in consonance with school authorities - usually the principal, vice principal or science department head. The exact survey timing - within a three to four week period - was left to the convenience of the school authorities. The field closing date was in fact extended by two weeks to accommodate two schools that were unable to conduct the survey earlier.

4. Sample consent forms (to be signed by parents, in the case of students below 18 years of age, and by the students themselves for those 18 years or older) were sent to these schools along with a confirmation of the classes to be included for the STS study. These forms were to be used by the participating schools to collect the required consents, prior to the actual 'fielding' of the instrument in the selected Grade 10 and 12 science classes.

5. Since the questionnaire was to be administered during a regular class period with the appropriate class teacher invigilating, all measures were taken to lighten their load as much as possible. As mentioned above, sample parent consent forms - or the required number of copies thereof where requested - were provided to all schools. Individual sets of questionnaires and envelopes for each participating class in a school were packed and labelled prior to their being dispatched to the school. In each set, the different versions of the questionnaire were pre-arranged in rotating order as a "built-in mechanism" to ensure their equitable distribution among participating students. Each copy of the questionnaire had completion instructions addressed to the respondent (i.e. the student in this case). Instructions for administering the data collection procedure were also provided separately, for the benefit of the school staff responsible for doing so. (See Exhibit 9) Intensive telephone contact was simultaneously maintained with the test facilitators in each school, to tackle questions and provide clarifications as they arose.

6. A courier company was used for the delivery of all materials both to and from participating schools.

7. The survey was in field during March and the first week of April of 1990.

5. FOOTNOTES

1. As well as in most industrialized countries.

2. Einseidel, Edna, Scientific Literacy: A Survey of Adult Canadians (Calgary, University of Calgary Program in Communication Studies, 1989).

3. Ibid. For the U.S. case, see Jon Miller, "Scientific Literacy", Paper presented to A.A.A.S., January 1989, San Francisco California. For the U.K. case, see John Durant, G.A Evans and G.P Thomas, "The Public Understanding of Science, Nature 340 , No. 6, July 1989.

4. Lynne Ainsworth, "Students shun science for arts," Toronto Star, 11 July 1990.

5. A recent Report of the Premier's Council on Science & Technology recommends that science be made compulsory up to Grade 12; however the report admits that S&T are presently made too boring for students, and they therefore recommend that the compulsory grade be initially set at Grade 10.

6. International Association for the Evaluation of Educational Achievement. Science Achievement in 17 Countries. A Preliminary Report (New York, 1988); Educational Testing Service. A World of Differences. An International Assessment of Mathematics and Science. (Princeton, 1989). See also, Newsweek Magazine, "Not Just for Nerds, How to Teach Science to Our Kids," 9 April 1990.

7. The federal government, for example, established a Program for Public Awareness of Science and Technology. It includes two separate components: a publicity campaign (including public advertising in print and radio, and contributions to provincial education organizations) and a granting program called "Science Culture Canada", which gives grants to organizations and individuals involved in public awareness activities and projects. Several provinces have their own public awareness programs as well, notably Alberta and B.C.

8. The National Advisory Board on Science and Technology advises the Prime Minister, and each province has its own advisory group. In Ontario, the Premier's Council on Science and Technology advises the premier. Provincial advisory councils meet together as well.

9. Science For Every Student (Ottawa: Science Council of Canada, 1984).

10. It is interesting to note, however, that there are a few important areas of STS that are not covered by the aims of the Ontario science curriculum. These areas deal with the influence of society on science and technology, and the social construction of scientific knowledge and of technology. The aims of the Ontario science curriculum are heavily weighted toward epistemology and the influence of S&T on society. See Section 4.1.1, where the aims of the Ontario curriculum and the STS areas covered by VOSTS are compared.

11. Science Curriculum Guideline. Part 1: Program Outline and Policy, p. 13.

12. Science Curriculum Guideline. Part 1: Program Outline and Policy, p. 22.

13. Science Curriculum Guideline. Part 1: Program Outline and Policy, pp. 10-12.

14. The relationship between science and technology is, in fact, more complex than this simpler picture of technology as applied science. However, the thrust of this aim is for students to realize that the two interact in real life, and that many career opportunities stem from this link, whether or not the student wants to pursue science itself.

15. Senior Division Advanced-Level Chemistry: Educators' Report (Toronto: Ontario Ministry of Education, [1988]). Senior Division Advanced-Level Physics: Educators' Report (Toronto: Ontario Ministry of Education, [1988]).

16. Aikenhead, G.S. Fleming, R.W. and Ryan, A.G., "High school graduates' beliefs about science-technology-society. I. Methods and issues in monitoring students' views," Science Education, 71 (2), (1987), 145-161. Other researchers have produced different instruments. The work in STS evaluation has been researched and presented in a Literature Review as part of this study. See Part Two

17. The requirement for a single instrument for both grades and all course levels was to allow for comparative studies over time that compare student responses as they move through the system.

18. A future study of considerable interest would be to design an instrument for grade 7 and use it to compare with grade 9 and 12. This would measure the change in views between entry level students into the first year of the intermediate/senior program, students entering high school science and students completing high school science.

19. See Appendix C.

20 Rosenthal, D.B., "Two approaches to STS education," Science Education 73 (5) (1989), 581-589.

21. Test on Understanding Science (Cooley & Klopfer, 1961), Nature of Science Scale (Kimball, 1965), Science Process Inventory (Welch, 1966), Test of the Social Aspects of Science (Korth, 1968), Nature of Scientific Knowledge Scale (Rubba, 1976), and the National Assessment of Educational Progress (Bybee, Harms Ward & Yager, 1980; Hueftle, Rakow & Welch, 1983).

22. For example, journals such as Science, Technology & Human Values, or Bulletin or Science, Technology & Society, and articles and books such as Aikenhead, G.S. , "Collective decision making in the social context of science", Science Education, 69(4), (1985), 453-475; Barnes, B. & Edge, D., Science in context (Cambridge, Mass.: MIT Press, 1982); Bybee, R.W. (Ed.), Science-technology-society. 1985 NSTA Yearbook (Washington, DC: National Science Teachers' Association, 1985); Fleming, R.W., "Literacy for a technological age", Science Education, 73(4), (1989), 391-404; Gauld, C., "The scientific attitude and science education: A critical

reappraisal", *Science Education*, *66*(1), (1982), 109-121; Snow, R.E., "Core concepts for science and technology literacy", *Bulletin of Science-Technology-Society*, *7*(5/6), (1987), 720-729; and Ziman, J., *Teaching and learning about science and society* (Cambridge: Cambridge University Press, 1980) and *An introduction to science studies: The philosophical and social aspects of science and technology* (Cambridge; Cambridge University Press, 1984).

23. The number of topics within each major section, and the number of sections themselves, may be expanded in the future. In fact, section three has been left blank in order to leave room in the framework for future items emphasizing the area of technological literacy. The VOSTS item pool currently emphasizes *scientific* literacy because this area was more fully developed in the STS area when the research began in 1984.

24. To ensure provincial representation, these six individuals included the incumbent Chairs of STAO and SCCAO.

25. Table 1 and Table 2 summarize the Ontario aims and the VOSTS topic areas respectively. A more detailed description of the Ontario aims can be found in Science Curriculum Guideline. Part 1: Program Outline and Policy, pp. 10-12.

26. Several schools were surprised by this procedure, as they did not realize the Act was in force.

27. For example, several items deal with the same issue, but come at the topic from different perspectives. This allows for consistency and comprehension checks.

28. For example, we found that students in basic grade 12 programs are extremely under-represented in Ontario, in both urban and rural regions.

29. One OAC class was included to provide a comparison to VOSTS data, which was designed with graduating high school students.

30. For example by administering the questionnaire in smaller segments.

PART TWO

A LITERATURE REVIEW ON EVALUATION AND STS ISSUES

1. INTRODUCTION

The importance of the science-technology-society (STS) theme in science education has been widely recognized. The past decade has seen increasing attention to STS being paid by science curriculum developers in Canada and other countries (Orpwood and Souque, 1984; Gaskell, 1982; Bybee, Harms, Ward and Yager, 1980; Bybee, 1987; Harms and Yager, 1981; Science for Every Student, 1984). As a result of this new emphasis, the Ontario Ministry of Education has incorporated STS issues into its new science curriculum guidelines for secondary education (Curriculum Guideline, Program Outline and Policy, 1987). In addition, a special Science and Society course for OAC has been developed (Part 15 of Curriculum Guideline, 1987).

The introduction of STS-style teaching in science classes has raised the question of evaluation. If we are to assess how effective is the incorporation of STS into the science curriculum, how do we go about doing so? Are the instruments that 'have been designed to measure student aptitude in scientific reasoning adequate to do the job for STS? Are entirely new kinds of instruments required, or can existing ones be adapted for the purpose? As an initial step to answering some of these questions for the Ontario context, a survey of the STS evaluation literature has been conducted. While the scholarly literature in the general area of STS is vast, the field of STS evaluation is only just developing - especially in the area of secondary school science, universities and colleges have been dealing with STS since at least the early 1970s, and there is an enormous literature in this area. For the purposes of this study, however, we have concentrated on work being done at the secondary school level. The following journals have been consulted for this survey, and would be useful for anyone interested in STS programs or evaluation:

- Science Education
- International Journal of Science Education (formerly the European Journal of Science Education)
- School Science and Mathematics
- Journal of Research in Science Teaching
- Studies in Science Education
- British Journal of Educational Psychology
- Educational Research
- Research in Science and Technological Education
- Science and Children
- Bulletin of Science, Technology and Society
- Science Technology and Human Values

This report presents the results of the literature review in four main sections:

Section One reviews the various definitions of STS that one finds in the literature. These definitions are placed on a continuum defined by ones' views of social action and of the importance of scientific reasoning for society and individuals.

Section Two discusses how and where STS has been implemented in science education. Programmes in North America, Europe and the Developing Countries are examined.

Section Three looks at specific evaluation instruments that have been or are being developed for STS. The discussion includes instruments for measuring STS-related skills and attitudes (for example scholarly research in psychology or pedagogy), and instruments being developed to evaluate specific teaching methods and courses.

Section Four summarizes some of the main research issues that are being studied, using STS evaluation and measurement Instruments. These include scholarly research issues as well as specific educational evaluation concerns.

2. DEFINING SCIENCE/TECHNOLOGY/SOCIETY (STS)

The goal of traditional science education has been the acquisition of scientific knowledge in the form of facts and processes which are largely theoretical. The traditional science curriculum focuses on preparing students for higher scientific education with little consideration for the everyday uses of science. Such a focus has been appropriate for preparing aspiring scientists and engineers for future careers. However, less than ten percent of the student population ever goes on to work in scientific/engineering/medical professions. The STS theme is seen as a way to address the needs of all pupils. As citizens they are involved in a multifaceted society. They are faced with daily decisions about food supplies, energy sources, population problems, health issues, environmental quality, war and peace, and technological advances. (Hofstein, Scherz and Yager, 1986.)

STS means different things to different people. In reviewing the scope of STS definition the "political" persuasion of each author must be kept in mind. On the left end of the "political spectrum" one finds the action oriented, socially motivated researchers and curriculum developers. On the right end of this spectrum one finds' the traditional science educators who believe that traditional "basic" science is more important than social relevancy.

Robert Yager (1984), from the University of Iowa, can be placed on the "left" end of the spectrum. He is a strong advocate of the STS curriculum. According to Yager:

> ...science education is defined, as the discipline concerned with the study of the interaction of science and society - i.e., the study of the impact of science upon society as well as the impact of society upon science. Their interdependence becomes a reality and the interlocking concept for the discipline. Research in science education centres upon this interface. (p.36)

Hofstein and Yager (1982) emphasize that "concerned" means that science education must respond to social changes, and that various societal issues should be reflected in school science programs. The goals of science education must be reformulated, they urge, to include the personal and social dimensions of science that have been ignored for over two decades. (p.541)

In the same "political" spectrum as Yager, one finds Reg Fleming of the University of Saskatchewan. According to Fleming (1987) STS education also deals with the sociology of knowledge. Fleming states that science should be seen primarily as a social institution interconnected to other social institutions such as education, government, and the military (p.164).

At the other end of the spectrum one finds proponents of the traditional science curriculum. Kromhout and Good (1983) disagree with the Hofstein and Yager position. They generally support "the use of socially relevant problems as motivation for a coherent study of fundamental science" (p.647). However, the ultimate aim of science education,they insist, must be "the coherent structure which is the heart and soul of the scientific method" (p.648). They complain that STS emphases are diluting the sound teaching of scientific problem solving:

> The computer, the technology of objectives and multiple guess, modularized individual study materials, science history, sociology of science, sociological impacts of technology (although each has made valid and valuable contributions to education), and even the antiscience of creationism have displaced the efforts to teach, through direct personal experience and problem solving, an understanding of the power and scope of the problems on which science can cast significant light as well as those questions of value judgment on which science does not lead directly to a solution. (p.648-649)

Kromhout and Good believe that any attempt to include socially relevant topics would distract science teachers from educating students about the structure and methods of science. Furthermore, they assert that use of social issues in curriculum organization is dangerous because social activists will manipulate and pervert science education. (p.650)

Bybee (1987) has taken the middle ground in defining STS and science education. Bybee sees science as a method conducted by people in a social context. Thus, he advocates three objectives for science education:

- scientific and technological knowledge,
- scientific processes,
- personal/social applications.

Bybee insists that STS education must have cognitive as well as social aims. A number of cognitive goals of science education (in the STS context) have been identified, by several authors (Yager, 1986; Fleming 1987; Bybee, 1987). These include:

- the development of reasoning,
- extension of the inquiry goal to include decision making,
- concern for the opportunities and requirements needed for a wide variety of careers,
- focusing instruction on exploration rather than "coverage",
- developing a favourable and accessible image of science and scientists.

The role of technology in society, and its relationship to science is considered to be an important aspect of STS. Fleming (1986) believes that the relationship between science and technology should be viewed as symmetrical. Technology is not applied science. Rather than depending on the culture of science, technology has its own separate cultural agenda. (See also Hurd, 1986)

Solomon (1988) believes that technology, in the context of STS courses, will mean neither the intricacies of microelectronics and mechanisms, nor those "big machines" that are the general public's equation to technology. Solomon states that students need to see technology as the application of knowledge, scientific and other, for social purposes. According to Solomon there is a long history of teaching the "applications" of knowledge which includes technology as applied science. This tradition assumes that the introduction of technology into society is unproblematic. This view, Solomon asserts, is contrary to the aim of teaching STS.

David Layton (1988), from the University of Leeds in the United Kingdom, also regards technology as a separate entity from science. According to Layton, technology must be recognized as an autonomous co-equal to, and not subordinate branch of, science. Layton believes that the analysis of contextual values (social, economic, aesthetic, moral and others) should be part of an attempt to understand the interactions between technology and society.

In contrast to the prevalent view that technology and science are distinct, albeit related, the Ontario Ministry of Education states in its aims of science education that technology must be learned as applied science. Granted this goal also includes understanding the interaction between science and technology. (Curriculum Guideline, 1987)

3. IMPLEMENTING STS IN SCIENCE EDUCATION

This section explores some of the STS programs that have been implemented in North America, Europe, and the Third World.

Since the late 1970s, at the university level, the involvement of ethics and values in the practice of science and technology has become a growing concern of a variety of researchers. In 1978, in the U.S., a national survey to determine the extent of academic activities in the field of science, technology, and human values in colleges and university, showed that courses or programs were offered in 919 institutions of higher education (American Association for the Advancement of Science, 1978). In addition, courses or programs related to STS; environmental concerns; health care; and contemporary moral and ethical problems related to science and technology were offered in 879 institutions, in the U.S. (Hurd, 1986; McConnell, 1982). However the present report will only deal with pre-university STS programs.

3.1. The United States

3.1.1. Forces Influencing STS Implementation

In the aftermath of the Soviet launching of Sputnik, science education in the United States concentrated on producing scientists and engineers through traditional science teaching methods (Bybee, Harms, Ward, and Yager, 1980). According to Paul Hurd (1970), of Stanford University, in the 1950s and 1960s science curriculum designers shied away from any direct consideration of the connections between "science, technology, society and the individual". Thus the majority of students held negative attitudes toward science, science as a career and scientists.

By the mid - 1970s, science educators and curriculum developers In the U.S. had sounded an alarm that science education was in a state of crisis. Hurd (1973) has identified a number of factors that were instrumental in developing this perceived crisis. Profound changes had occurred in American society and there was increased dissonance in American culture. Public disenchantment with science and suspicion of technology worked hand-in-hand with a prevailing lack of confidence in schools. The consensus emerged that science education in the U.S. was in need of change.

According to Hurd (1986, 1973, 1970) the key issues in the reform movements of the 1970s and the 1980s were:

- the purposes of science education,
- the context of the science curriculum,
- the scientific subject matter most worth knowing,
- the conditions that foster that knowing.

A National Science Teachers Association (1978) study identified the following factors as related to the crisis in science teaching:

1. decline in student population;
2. increasing diversity among students;
3. decline in local and national funding;
4. loss of public confidence in science and public education;
5. decline in science course enrolments;
6. unfavourable student attitudes toward schooling;
7. science curricula unsuited to current needs;
8. inappropriate pre-service and post-service teacher education
9. unionization of teachers;
10. mandated accountability. (McConnell, 1982)[1]

Project Synthesis (Harms and Yager, 1981), a two-year study of "the countenance of science education" supported by the National Science Foundation, resulted in the following recommendations:

1. "A major redefinition and reformulation of goals for science education; a new rationale, a new focus, a new statement of purpose are needed. These new goals must take into account the fact that students today will soon be operating as adults in a society which is even more technologically.oriented than at present; they will be participating as citizens in important science-related societal decisions. Almost total concern for the academic preparation goal as is currently the case is a limiting view of school science".

2. "A new conceptualization of the science curriculum to meet new goals; redesign of courses, course sequences/articulation, and discipline alliances are needed. The new curriculum should include components of science not currently defined and/or used

in schools. Direct student experiences, technology, personal and societal concerns should be foci" (Harms and Yager, 1981).

3.1.2. Specific Programs

Largely influenced by Project Synthesis, in the early 1980s the National Science Teachers Association began its search for formulating a new science curriculum. The Search for Excellence program was developed in 1982 (Yager, 1986).

Criteria (ideal state conditions) were formulated in five categories: science in the elementary school, biology, physical science, science as inquiry, and science/technology/society (Yager, 1986). In the summer of 1982, 50 programs (approximately ten in each of the five categories) were selected as national exemplars from the 170 identified by the 50 state committees during the spring.

Some other STS programmes in the United States include:

SCIENCE IN THE MARKET PLACE in Scotch Plains Fanwood High, New Jersey;

HOUSE HOLD CHEMISTRY AND PHYSICS in Spartanburg High School, South Carolina;

TOPICS IN APPLIED SCIENCE in Jefferson County, Colorado (For more examples of STS programs see Hofstein' and Yager, 1982)

According to Bybee (1987) in most science programmes the STS component will be greater and more intense at higher grade levels. In the U.S., Bybee found that the minimum amounts of instructional time being devoted to science-related social issues are the following:

- in elementary school 10 percent;
- in middle/junior high school 15 percent;
- in high school 20 percent;
- in college/university 25 percent.

3.2 United Kingdom

3.2.1 Forces Influencing STS Implementation

According to Joan Soloman (1988) a major force in the launching of STS in the U.K. was the notion of scientific responsibility as a reaction to the making and the dropping of the atomic bomb. (Even before that - in 1939 - the first major STS-style work, J.D. Bernal's Social Function of Science had been published in the U.K. This opus established an STS tradition in that country.) Solomon states that another force was the new philosophy and sociology of science. Soloman claims that the denial of science as value-free knowledge, indicates both that the nature of science should be studied, and that the open discussion of the social effects of science-based issues should be an objective of education.

On the other hand Ziman (1980) states that STS in Britain has its roots in rebellion against the traditional system of specialization which marks students either as university bound science student or non-science oriented student. In STS education students are seldom being taught specifically for entry to a more advanced level in the same subject, and have no reason to pretend that they are working their way up to scientific careers. Ziman points out that in this field of education the real needs of the majority of students in each course must be sincerely respected.

3.2.2. Specific Programs

The Nuffield Foundation Science Teaching project was an early effort by the British to include social concerns in science curriculum. In 1962 a Parliamentary Question was raised in the House of Commons about the steps being taken by the new Curriculum Study Group to improve the teaching of science and mathematics. In reply, the minister of education announced the setting up of the Nuffield Foundation Science Teaching Project.

According to Mary Waring (1979), the Nuffield Project represented a major landmark in British educational practice. It was the first effort to develop an articulated and comprehensive set of tested teaching materials in an attempt to achieve coordinated and widespread reform in science and mathematics, in secondary schools. An example of this program was the "Nuffield Physics Program". Waring believes that the Nuffield Project was based squarely upon a set of assumptions which, in part, reflected a history of science education peculiarly "English".

The Association for Science Education (ASE) is the main professional body of science teachers in the U.K. The Association has published two general studies programmes for post-16 years-old students in schools and colleges: SCIENCE IN SOCIETY (the first British high school STS programme), and SCIENCE IN A SOCIAL CONTEXT (SISCON) (Solomon 1988). SISCON was inaugurated in 1971 to foster the study of STS in science courses at the university and polytechnic level. The British Science, Technology and Society Association, which was formed in 1977, was a direct descendent from SISCON. A more recent STS program in the U.K. is SCIENCE AND TECHNOLOGY IN SOCIETY (SATIS), implemented in 1986. The SATIS project is for young people in the 14-16 age range. In addition a new SATIS project for 16-19 year-olds is in preparation (Hunt, 1988).

In Great Britain STS programs have mostly been implemented in the senior levels of secondary school and post-secondary school. The current version of British 0-level exams includes an STS component.

The United Kingdom has not been the only European country involved in STS education. In the Netherlands for example, a STS program called Physics Curriculum Development Project (PLON) has been implemented. In this project physics curricula for general secondary education has been developed in which STS-aspects have been incorporated (Eijkelhof and Lijnse, 1988).

3.3 Canada

3.3.1. Forces Influencing STS Implementation

In Canada an STS curriculum has been developed or is being developed in each of the provinces since the early 1980s. The impact of the "crisis" in science education from the

1970s to the early 1980s in the U.S. (and the U.K.) was felt in Canada as well. The Canadian crisis was the result of cutbacks in support for curriculum projects, research, and staffs of science education centres. In contrast to the 1960s where prominence was given to science courses, the 1970s and the early 1980s back to the basics movement generally excluded science as a basic (Gaskell, 1982).

The Science Council of Canada has been very influential in identifying the importance of STS for science curriculum development. Science for Every Student (1984) was the product of a comprehensive study of science education in Canadian schools begun by the Council in 1980. The research program, designed by the Council's Science Education Committee in cooperation with every ministry of education and science teachers' associations in Canada, was carried out in each province and territory by some 15 researchers. Interim research reports, discussion papers and workshop proceedings formed the basis for a series of nationwide conferences during which parents and students, teachers and administrators, scientists and engineers, and representatives of business and labour discussed future directions of science education (for more information on the study see the background study in three volumes; Orpwood and Souque, 1984; Orpwood and Alam, 1984; and Science Education in Canadian Schools. Volume III. Case Studies of Science Teaching, (1984).

The Science Council of Canada report Science for Every Student (1984) offered several pertinent recommendations to science educators. These included:

- "Science education must provide a more accurate view of the practice, uses and limitations of science.

- Science education must include study of how science, technology and society interact.

- Students must be taught how Canadians have contributed to science and how science has affected Canadian society.

- Teachers and curriculum planners must evaluate students' progress towards all the goals of science education, not just their learning of scientific content."

The idea that science should be presented as part of Canadian culture and used to foster the creation of a Canadian identity had already been forcefully argued in a discussion paper distributed by the Science Council of Canada (Page, 1979). It argued that Canadians are ignorant of Canadian accomplishments in science and technology, of the way science and technology shape Canadian society and of the need to focus Canadian research on specifically Canadian problems.

3.3.2. Specific Programs

The STS component in science curriculum has been implemented in two ways: either as a specific course or program, or as an STS theme integrated into traditional science courses. An early example of a Canadian STS course is SCIENCE: A WAY OF KNOWING created by Aikenhead and Fleming in 1975. The grade ten course developed in Saskatchewan, touches upon cultural influences on science. It is divided into three sections. In the first section, students investigate some of the different ways their community gains and uses knowledge, such as through economics, religion, art, and politics. In the second section, science is studied in more depth as one of the ways in which the community is affected by science and the ways in which science is affected by the community (Aikenhead and Fleming, 1975).

Another example of an early Canadian STS course is SEPARATION OF SUBSTANCES (Roberts, McLeod and Orpwood, 1981). SEPARATION OF SUBSTANCES is built around a simulation in which students develop technical advice about water supply treatment for a fictitious island community. According to Gaskell (1982) conflict over a curriculum such as SEPARATION OF SUBSTANCES is likely to arise between scientists, who see it in their interests to foster an image of science as being value free, and political groups interested in challenging that image.

A more current example of an STS program in Canada is the SCIENCE AND TECHNOLOGY 11 in British Columbia. Two B.C. Provincial Science Assessments, in 1978 and 1982, each tested student understanding of science and technology issues. The Interpretation Panels for the 1982 Assessment at both the grade 8 and grade 12 levels reported that they felt these issues were insufficiently stressed in most teaching. The 1982 report recommended "that science teachers give more emphasis to teaching the practical applications to science knowledge and to using the knowledge in new situations" (Science and Technology 11, Curriculum Guide, 1986, P.1).

This recommendation was instrumental in designing SCIENCE AND TECHNOLOGY 11 in 1984. In September 1986, this new STS course was implemented and taught on a provincial scale to approximately 6,700 grade 11 students. The nature of the ST 11 classes was reported to be almost evenly divided between "even mix" (academic/non-academic students) and "non academic".

According to the SCIENCE AND TECHNOLOGY 11 curriculum guide, this program addresses the need to provide students with the attitudes, knowledge and skills necessary to become active, informed decision makers in tomorrow's world. The evaluation of ST 11 is discussed below.

3.4. The Less Developed Countries

STS education in the non-western world, specifically the Third World, has its roots in developmental needs. This factor is important in the way STS is implemented and the restrictions that are imposed upon it. According to Vardhini, in Less Developed Countries (LDCs) the STS approach is essential in education and in science teaching, where it plays a fundamental role in the country's development process (Vardhini, 1982).

An example of an STS oriented program in the Third World can be found in Nigeria. The science curricula for primary schools that are developed draw inspiration from the SCIENCE EDUCATION PROGRAM FOR AFRICA (SEPA). SEPA has influenced the development of Integrated Science for Primary School in Nigeria, which places emphasis on exploration and investigation of the child's environment (Adeniyi, 1987).

Adeniyi (1987) uses four levels of organization in implementating STS in Nigeria: design blue print, construction, implementation, and evaluation. According to him, the design stage involves stating broad national objectives without giving details about the feasibility of such objectives. In this stage a carefully detailed enumeration of the curriculum content and suggested general operational plans are provided. In the construction stage specific steps are taken towards production of textbooks, manuals, workbooks, and equipment. At the construction stage the "what" and the "how" are stated in clear terms and trial testings are conducted to "feel out" the feasibility of the program within the class room. The implementation stage deals with teacher-student-material interactions; lesson notes, textual materials and laboratory activities are planned and executed in class. Attempts are made to organize materials so as to suit prevailing local conditions. The evaluation stage dwells primarily on assessing the worth of a program. Unstandardized local and standardized national tests are used to evaluate student's level of performance.

In implementating STS in the LDCs in addition to the usual STS objectives such as science being learner-centred, teacher assisted, action oriented, project based, and topical, Rugumayo (1987) emphasizes that its foundation must be firmly embedded in the socio-economic and cultural milieu of each country. Science education in the Third World must use the current indigenous techniques, arts, crafts, medicine and agriculture. STS in the LDCs should integrate the old and new, the national and international, traditional and western medicine, traditional and modern agricultural practices and traditional and modern technology.

According to Rugumayo (1987) science education in the LCDs, should aim to promote agricultural development, industrial production, and scientific research, which would lead to social development as well as modernization.

Elstageest (1987) insists that no amount of foreign knowledge would solve the specific problems of any nation. Knowledge and insight must develop from within so as to tackle the problems which arise from within. Thus, the aim of education in LCDs should be self reliance. If self reliance is greatly enhanced by the training in and application of the process of science, then it is not difficult to establish a relationship between science and development.

The obstacles facing the LCDs in implementing STS education are many fold. Rugumayo (1987) underlines the importance of not alienating scientifically trained youth from the rest of the population. This challenge can be met by teaching culturally relevant science, and by involving the community in STS education. Rugumayo also believes that many scientists in the LCDs have found it difficult to apply what they have learned. Science education therefore, should emphasise how to apply scientific knowledge and methods in tackling practical problems at individual, local and national levels.

Adeniyi (1987) notes the problem of teaching science (STS or non-STS education) courses in English. Some problems inherent in learning science, mathematics and technical/vocational subjects through English include: inadequate knowledge of English, inadequate mastery of mother tongue, and a lack of congruecy between English and the mother tongue.

In summary it appears that STS applications in LCDs are just as crucial (if not more so) as in the developed countries. The restrictions facing the Third World imposes problems in implementing STS education in many countries.

3.5. Teachers' Reaction towards STS Implementation

According to Yager and Penick (1986), to effectively implement any STS program there are four criteria that must be met:

1. Significant involvement of local communities in program development and instruction
2. STS as a curriculum focus
3. Labs defined as the real world (unlike the traditional laboratories which were devoted to confirmation rather than investigation)
4. Focus first on qualitative considerations and later on quantitative ones (p.7).

Furthermore, the authors stress that the science teachers, themselves, must be ready to take the responsibility and the initiative for implementing the STS component in their science programmes. If science educators are not supportive of STS programmes and willing to implement STS oriented courses, STS courses will be ineffectual. Students' attitude toward the program will be adversely affected as well (Yager and Penick, 1986).

Bybee (1987) has noted that some science teachers are not prepared to implement the STS theme. Bybee believes that researchers in science education should provide instructional materials, in-service programs, methods textbooks, and summer-school classes that will prepare teachers to implement the STS theme.

In the U. S., Carol Mitchner and Ronald Anderson (1989) examined 14 secondary teachers' perceptions of a model STS curriculum designed to promote scientific literacy. They determined how science teachers perceived the STS curriculum, and analyzed the influence those perceptions have on their teaching decisions. They also explored curricular issues from the frame of reference of teachers, the key factor in successfully implementing innovations.

The result of the study revealed that whether teachers accepted, altered, or rejected the course, they shared similar concerns about the development and implementation of this multidisciplinary curriculum. These concerns included:

- concerns over content,
- discomfort with group work in the classroom,
- uncertainties about evaluation in the classroom (the problem of testing subjectively),
- frustration about student population (the students were perceived as under-achievers),
- confusion over the teacher's role (p.352).

According to Mitchner and Anderson, in the area of curriculum change, the classroom teacher is the key figure in determining the success or failure of a new curriculum. Mitchner and Anderson believe that:

> the value and belief system that dictated this teacher role was well defined and somewhat rigid. It did not allow for new approaches, such as STS curricula, to become easily incorporated and internalized into daily practice. This study supports the need for significant attention to teachers' beliefs and value system. Many innovations, such as an STS curriculum and the inquiry programs of the recent past, are inconsistent with current beliefs and values of teachers. The seeker of change is faced with a choice between moderating the extent of such innovations or attempting to influence these [traditional] deep-seated beliefs and values (p.353).

Bybee and Mau (1984) conducted a survey of teachers from 41 countries to study the reaction of these educators toward science and global problems. They found that the majority of participants in the study supported STS themes in science education and were willing to experiment with new STS programs. There were some reservations, however, about how prepared they felt to implement the new programmes.

4. THE INSTRUMENTS AND THE METHODS USED IN EVALUATING STS

Traditionally the instruments used to access science performance have evaluated scientific knowledge or/and cognitive dimensions. Some of these instruments can be adapted to evaluate the STS component in science education. It has been only recently that specific instruments have been designed to measure students attitudes toward STS. In this section, the limitations and potentials of certain instruments and the results of certain tests will be explored.

4.1. Terminology

In designing evaluative instruments several factors have to be taken into consideration to check the potentials and limitations of evaluation instruments (Harty and Beale, 1984).

Test-retest reliability is the degree to which an instrument's total score is consistent over time. It is used as an estimate of reliability in cases where an instrument is administered to the same group of individuals on two occassions. Reliability testing is appropriate when it is likely that subjects taking the instrument the second time will not remember responses made the first time. The coefficient after correlating the two sets of scores is often called "coefficient stability".

Predictive validity is criterion-related validity. It is concerned with the degree to which predictions made by a developing instrument's overall score are confirmed later by a performance index of the same subjects. It also relates to predictions of how well individuals will do in a future situation.

Construct validity is subjective appraisal of what the construct of an instrument measures. Construct validity is established by determining the relevancy of the substance of an instrument's items. It is interpreted as the degree to which an instrument appears to measure what it purports to measure.

4.2. The Domains of Evaluation in STS Education

According to Yager and McCormack (1989) certain domains should be taught in science education and the effectiveness of these domains must be tested.

The information domain is explained as knowing and understanding which includes: facts, information, laws (principle), existing explanations, and theories being used by scientists, and internalized knowledge which can be used.

How scientists think and work portrays another aspect of science. Science education in the process domain includes: observing, classifying, measuring, communicating, predicting, hypothesizing, testing, identifying, interpreting data, and constructing instruments, and physical models.

The creativity domain in STS education include: visualizing (producing mental images), combining objects, solving problems, fantasizing, designing devices and machines, producing unusual ideas, identifying, isolating, merging, diverging, converging.

The current social and political institutions, environmental and energy problems necessitates the inclusion of human feelings, values, and decision-making skills in science curriculum development and program evaluation. The attitudinal domain includes: developing positive attitudes toward science in general and in school, science teachers, and science careers; making decisions about personal values, making decisions about social and environmental issues, and exploring arguments on both sides of an issue.

In the last domain science is used and applied in students' everyday lives. Some dimensions of this application domain are: seeing instances of scientific concepts in everyday life experiences; applying learned concepts and skills to everyday technological problems; understanding and evaluating mass media reports of scientific developments; integrating science with other subjects; becoming involved in community-action projects; extending school experience beyond the classroom; and emphasizing the interrelationships and interconnectedness of science to other human endeavours (p. 46).

In designing the traditional science curriculum the information domain has been the starting point. In designing STS education, Yager and McCormack (1989) stress the importance of starting with the real world. The world of applications and connections acts as a pathway to important and valuable facets of scientific knowledge and process. They point out that to start with the information domain and to move to the application domain is difficult for many students. Such an emphasis encourages many students to differentiate between real world science (founded on personal experiences) and school science (based on information and included in textbook and course outline). Most educators and curriculum developers would agree, Yager and McCormack claim, that the aim of science courses for all students to apply the information and connect facts to everyday experiences. However, little instruction is concentrated in the application domain; which is the major difference between STS and traditional science instruction.

Since STS education can be based on these five domains, Yager and McCormack can stress that STS evaluation should also assess student growth across multiple grade levels and in the five domains.

4.3. Evaluation Instruments

The instruments have been organized into five categories according to the methods they use and the domains they measure. The five categories are:

1. Multiple-choice instruments,
2. Likert-type instruments,
3. Essay instruments,
4. Interview instruments,
5. Views on Science-Technology-Society (VOSTS).

4.3.1. Multiple-choice Instruments

Most of the standardized instruments that were developed in the 1960s to quantify student understanding of science were in multiple-choice format. TEST ON UNDERSTANDING SCIENCE (TOUS) is an early example of such an instrument. TOUS is a multiple-choice instrument developed to measure Harvard-sponsored case studies. It is a 60-item, 4-response multiple-choice test. The items are categorized into three subscales (Aikenhead, 1973):

Subscale I. Understandings about the Scientific enterprise (18 items)
Subscale II. The scientist (18 items)
Subscale III. Methods and aims of science (24 items)

An example of the use of multiple-choice is found in a study conducted by William Baird and Gary Borich (1987). They examined the connection between integrated science process skills (ISPS) and formal reasoning ability (FRA). They assess the importance of this correlation toward curriculum design and science teaching. According to the authors if one trait can be enhanced through effective teaching, with subsequent improvement in the second trait, then efforts to manipulate teaching styles, inquiry activities, and process-centered curricula to advance this "driver trait" would be warranted. The study shows a high correlation between ISPS, as defined by the American Association for the Advancement of Science (AAAS) and FRA as measured by pencil and paper version of the Piagetian interview.

Two independent tests of the AAAS science process skills were used for the study. The Test of Integrated Process Skills (TIPS) was produced by researchers at the University of Georgia (1980), and the Process Skills of Science Test (PSST) was developed at the University of Connecticut (1972). TIPS is a 36-item, 4-response multiple-choice test. The PSST is a 48-item, 5-response multiple-choice test. The authors use raw scores, without attenuation for guessing.

In addition, two independent tests of formal reasoning ability were used in the study. The Group Assesment of Logical Thinking (GALT) was also developed at the University of Georgia (1983). The other test - "Classroom Test of Formal Operations" (CTFO) - was produced by Lawson in 1978. The GALT is a 21-item, double-response multiple-choice instrument, using line drawings to present Piagetian problem situations. The CTFO is a 15-item, double-response multiple-choice test which utilizes a videotape presentation of an adult male presenting the Piagetian problem and posing the question. To be scored as correct, items on both of these tests must be answered correctly and have a correct reason for the answer (double multiple-choice format). The four tests were used on 54 subjects from three educational-psychology classes for pre-service elementary-education majors.

Baird and Borich attribute the high correlation between the GALT and TIPS tests to the common philosophical and/or theoretical orientation among test authors. Both of these tests were constructed by science educators working within the same research environment. Any particular orientation to science teaching outcomes within this environment could serve to lessen distinctions between test development projects. An interesting secondary finding of this study was the absence of any significant correlation between the number of science courses taken and integrated science process skills.

The limitations of multiple-choice instruments are discussed by Aikenhead (1988). Aikenhead notes the consistent and significant overestimation of student understanding of biological ideas when students were evaluated by a standardized multiple-choice test. Their choices on the test did not necessarily reflect their understanding of biology, an understanding which evaluators thought was being expressed (Yarroch, 1986).

On the other hand Aikenhead is a strong supporter of empirically developed multiple choice instruments. In his own work (1988) "student positions" for use in a multiple choice instrument were empirically developed by analyzing a large number of student paragraphs. The results of his study supported the efficacy of a multiple-choice format for evaluating student beliefs, provided that the choices are empirically derived rather than being deduced from a philosopher's view of science. According to Aikenhead, the "student positions" were written in a style that tried to capture a common argument among student responses; they were not written in a traditional multiple-choice style.

Aikenhead's instrument, Views on Science-Technology-Society (VOSTS) will be discussed in Section 4.3.5.

4.3.2. Likert-type Instruments

Likert-type tests are probably the most popular and yet controversial instruments used to measure attitudes. Despite their many shortcomings, Likert scales have been used to measure the strength of group opinion, and to measure the "intensity" of attitude responses. In a Likert-type test students place themselves on an attitude continuum anchored by the positions "strongly agree" and strongly disagree" with "undecided" as a neutral mid-point. In some cases, the neutral position is omitted, forcing respondents to choose a position. This section will explore certain instruments and some cases in which they have been used.

Early Examples of Likert-type Instruments

Aikenhead (1973) describes some of the early Likert instruments developed in the U. S. NATURE OF SCIENCE SCALE (NOSS) was created in 1965 and TEST OF THE SOCIAL ASPECTS OF SCIENCE (TSAS) in 1968. The NOSS measures opinions about the nature of science. The development, validation and reliability measures of the NOSS were carried out with college graduates. Thus the NOSS lacks reliability and validity data relevant to high school students.

The TSAS deals with "the interaction between science and society and those features which are related to the social nature of the scientific enterprise itself" (p. 543). There are fifty-two statements to which the student responds on a five point scale, from "strongly disagree" to "strongly agree". The statements were derived from a model which suggested three subscales:

Subscale I. Interaction among science, technology and society (19 items)
Subscale II. Social nature of the scientific enterprise (21 items)
Subscale III. Social and political responsibilities of scientists (12 items)

Another popular test that was developed in the 1960s was SCIENCE PROCESS INVENTORY (SPI). It is a 150 item forced choice 2-scale instrument developed in 1966 by which scientific knowledge evolves (p. 543). On the basis content, the SPI resembles the TOUS subscale III. The validation of SPI followed the following procedures:

- using the literature,
- devising a model,
- employing the judgement of "experts",
- getting the feedback from preliminary studies,
- testing the instrument for its ability to distinguish among different groups of examinees.

The SCIENCE ATTITUDE INVENTORY (SAI) (Moore and Sutman, 1970) is an extremely popular Likert-type instrument used to measure students attitude toward science. The SAI is composed of 60 items arranged in a statement format with a five-point Likert-type scale for responses. It has two scales; one consisting of positive items and one consisting of negative items. A total attitude score is obtained by subtracting the negative scale from the positive scale.

Hugh Munby (1983) of Queens University has studied the validity of SAI. He was interested in the way conceptual analysis may be used to investigate the validity of a research instrument such as SAI. Many of the items in SAI which might be thought to tap attitudes, Munby claims, can be interpreted quite differently.

Munby also questions the conceptual validity of the SAI. He is primarily concerned about the instrument's inclusion of both realist and instrumentalist perceptions within each subscale. The inclusion of both perceptions, he feels, makes the SAI more useful across a broader range of personality/attitude types, rather than measuring specific attitudes (such as scientific attitude). Munby believes that SAI needs reworking before it can be used with confidence.

Munby (1982) also conducted a study that examined the impropriety of "Panel of Judges" validation in science attitude scales. According to Munby a test is valid if and only if the judgement given by a panel has the same contextual meaning as the subjects. In science curriculum evaluation, the "Panel of Judges" includes researchers, test developers, and science educators. The subjects are children or others less articulate in science than the "judges". Munby believes that there can be no certainty that the panel has the same context for interpreting the meaning of test items that the subjects have.

To avoid mistakes in context Munby suggests that researchers should interview the subjects and ask them the exact meaning of their answer and its context. In this way researchers can avoid the potential pitfall of the "doctrine of immaculate perception", by which researchers assume that their perception of the item corresponds to students' perceptions (see also Aikenhead 1988).

According to a study conducted by Gardner (1987) standard methods of attitude measurement, such as Likert and semantic differential scales, ignore the posibility of ambivalence. In particular, they do not distinguish ambivalence from neutral responses. This neglect arises out of the assumption that positive and negative affects towards a particular psychological object are bipolar, i.e.: uni-dimensional in opposite directions. Gardner contends that this is an untenable assumption. Conventional items that test internal consistency, he claims, are ineffective in checking this assumption. It is possible for a scale to be multidimensional and still display apparent internal consistency.

Gardner concludes that attitude researchers should not rely upon item statistics. They should test internal consistency data for evidence of the multi-dimensionality of their scales. Factor analysis should be routinely employed to check dimensionality. If statements reflecting positive and negative affects lead on independent dimensions, these should be scored separately and their relationship with other variables analyzed separately (p. 248).

A cautionary note has been sounded by Hazelwood (1989) in England about data gathered using Likert responses without checking the ability equivalence of different groups. He gave 4,000 fourth-year students from 23 schools in northern England 24 Likert response items in a questionnaire. He found that those in the lowest-ability group consistently chose more extreme responses than those in the highest-ability group. Replication gave further weight to these results.

In this study Hazelwood presents evidence to support the hypothesis that the less able tend to choose more extreme responses. He points out that, "there are people who say 'very strongly' to every question". He calls this tendency to use or not to use strong adjectives "generalized verbal intensity". He notes that various personality traits (inferiority, hypomania, psychophathic-deviate, depression) have been reported as being correlates of generalized verbal intensity, but general ability has not been thus recorded.

Hazelwood suggests that some people resort to "always" and "often" response sets when the items are too difficult. He suggests further that one sort of response set is to choose extreme responses. For example, he asks whether, perhaps, for some 14-year-olds it is too difficult a task to discriminate on a five-point scale. Hazelwood points out that there is general agreement that semantic/cognitive discrimination is related to ability. He notes, however, that its importance in relation to the validity of much survey data is not so generally recognized.

In another study conducted by Shrigly and Koballa (1984) the emotional intensity of Likert type science attitude statements was measured. The authors found that emotional intensity can be used to distinguish the attitude concept from other related psychological concepts. They suggest that science educators who design or modify science attitude scales should continue using item-total correlations and other quantitative judgements are also necessary. In addition they recommend that the frequency distribution of data generated by each statement should be examined for skewness and high percentage of neutral responses. Both factors can impair emotional intensity of an item.

The study concludes that science educators who design or modify Likert-type attitude scales should rely on more than psychometric measures in judging the validity of an attitude statement.

Aikenhead (1988) stresses the limitations of Likert-type instruments for the STS domain. Noting that Likert-type responses offer only a guess at student beliefs, he believes that the chances of an evaluator guessing accurately are remote. Aikenhead believes that "the almost ideal, unidimensionality of Likert items lies in sharp contrast with the multidimensional aspects of authentic science with its socio-technological context ... Therefore, one might have predicted the inadequacy of Likert-type scales for monitoring student beliefs about STS topics" (p. 617).

Despite the limitations listed above, Likert-type instruments are still used in measuring attitudes. Some examples of evaluation using Likert scales are discussed below.

Kevin Finson and Larry Enochs (1987) used the SAI to test how visits to science-technology museums affect student attitudes toward STS. They examined factors such as prior classroom experience with STS, instructional methodology employed by teachers, grade level, socioeconomic status, school type (private or public), and student gender. Data was collected by a pretest-postest control group design by using study-specific questionnaires and the Scientific Attitudes Inventory (SAI).

A teacher questionnaire and a student questionnaire were each developed to assess the extent to which STS was included in the classrooms used in the study. The student version contained two additional items allowing the researchers to assess students' socio-economic status. Neither questionnaire was designed with the intent to measure attitudes. Data from these instruments was obtained to establish the extent of STS inclusion in course work as a possible factor influencing attitudes toward STS (p. 598).

The SAI was selected by Finson and Enochs because some of its subscales appeared to address STS-types of concerns. Subscale 4 deals with science and technology relationships in a value-oriented manner. Subscale 5 focuses on science and societal relationships - although more on a cognitive than value-oriented basis. Finson and Enochs claim that the cognitive aspects of Subscale 5 are appropriate for use in the research, because "much of the focus of the STS theme and programs deal with technology, which by its very nature requires cognition" (p. 598).

The study takes into consideration Munby's criticism of the SAI's validity (Munby, 1983). Finson and Enochs acknowledge the limitations of attitude measures and the absence of adequate methods of determining the validity of attitude scales. With this in mind, they assessed the content of items in SAI subscales 4 and 5 and found it to be "appropriate" for their study. Results of the study indicated that significant differences in attitudes were present between visiting and non-visiting students and between grade levels.

No significant differences were found between other factors (socioeconomic status, gender, private/public school type, and teacher characteristics).

Hofstein, Scherz and Yager (1986) compared students' attitudes toward science in the U. S. and Israel. Students' attitudes were measured by using the National Assessment of Educational Progress (NAEP) instrument which uses a multiple choice format. In assessing student attitudes they used booklet four of the NAEP which uses a Likert scale. The students had to select one answer that ranged from very positive to neutral to very negative.

The study showed that:

- U. S. 13 and 17 year-olds both report that their teachers "really like" science more often than do Israeli students;
- U. S. teachers of 13 and 17 year-olds are more anxious for their students to point out their errors than are Israeli teachers;
- U. S. teachers of both 13 and 17 year-olds are perceived as willing to share opinions about science-related societal problems more than are Israeli teachers;
- U. S. 13 and 17 year old students perceived the science content they study to be more immediately useful to them than do Israeli students;
- Israeli 13 and 17 year-olds more often believe that their science studies will be useful in the future than do U. S. students;
- More U. S. 13 and 17 year-olds report that their science classes are boring than do Israeli students;
- More Israeli 13 and 17 year-olds report liking to go to science classes than do U. S. students (p. 28).

The authors suggest that such a binational study helps with the identification and understanding of students' perception of the science education they experience. Differences and similarities in the two countries may provide some explanations for the results. According to the authors the discrepancies between students' attitudes in the U. S. and Israel may relate to the differences in the educational systems, science teaching programs, and curriculum implementation procedures. They identify some differences that might be relevant:

1. teachers preparation
2. the centralized educational system in Israel
3. the Matriculation Examination in Israel.

Khalili (1987) assessed the effects of cultural differences between Australia and the U. S. on STS evaluation. He used the "Test of Science Related Attitudes" (TOSRA), which was developed in Australia, to evaluate students in Chicago. TOSRA is a multi-dimensional test with a sound conceptual basis. It is a 70 item test in a Likert-type format. It consists of seven scales with 10 items for each. These scales are:

1. social implications of science,
2. normality of scientists,
3. attitude to scientific inquiry,
4. adoption of science,
5. enjoyment of science lessons,
6. leisure interest in science,
7. career interest in science (p. 128).

As mentioned before, some instruments have been developed specifically to assess an STS program. In assessing the effectiveness of British Columbia's Science Probe 10 in 1986, three Likert-type scales were developed. The "Science in Society Scale", "School Science Scale", and "Careers in Science" were used. These scales were derived or taken from the 1982 B. C. Science Assessment (B. C. Science Assessment, 1986).

The Science in Society Scale attempts to measure a broad range of subjects. One of them is the interrelationships and interdependencies of science, technology, and society. The results indicated that the program was well received by teachers, but that they were concerned about the lack of lab experiments. Most students and teachers viewed Science Probe 10 as more worthwhile than the old program. The results showed that student interest and motivation had at leat remained constant, if not improved. The new program has tended to increase the amount of student reading from the text book, and discussion of science issues and values on society. Science students indicated that the program was more relevant and interesting.

4.3.3. Essay Instruments

Essay questions and short answer questions have been widely used to measure student attitude and knowledge. An example of a testing instrument using the essay format is the British Joint GCE O-level and CSE Examinations pertaining to STS topics. The exam contains sections on theory application, technology/society interaction, morality of science, science/society interdependence, the role of industry in society, and testing of knowledge. A specific topic included in the exam is the Chernobyl accident in the former U. S. S. R. Students are asked to give written responses after reading a newspaper article about the accident. (Joint GCE O-level and GSE Examinations, 1987).

The limitations of such essay-type instruments in evaluation has been studied by Blum and Azencot (1986). According to them, there is always a problem of unreliability due to objective scoring.

Furthermore, students seem to prefer multiple-choice over essay questions. In their study, students were given a choice of essay and multiple-choice items. A large majority of students chose the multiple-choice items. This was despite the fact that the various answers in the multiple-choice items could give hints to those students who answered essay-type questions. Few students chose to answer essay questions, nonetheless. Blum and Azencot further show that multiple-choice questions proved to be much more reliable, without subjective influence in the scoring of the test.

Aikenhead (1988) also discusses the deficiencies in using student paragraphs to measure attitudes. He points out that graduating high-school students are not necessarily the most articulate writers. In his study, some students failed to provide critical information in their paragraphs about STS topics.

In addition, Aikenhead notes that ambiguity can occur when students are uninformed on a topic, or when they do not fully understand key terms. An unambiguous paragraph is one for which the student and the researcher independently pick the same "student position" (the student, based on his or her true belief; the researcher, based on his or her reading of the paragraph). An ambiguous paragraph, on the other hand, is one for which there is no such agreement. Thus, Munby's notion of "immaculate perception" can apply to student writing as well (p. 617).

Despite the limitations of the method, there are some researchers who use this type of instrument. In Australia Collis and Davey (1986) developed a set of science items to test a variety of intellectual skills deemed important in secondary school science. They wanted to assess students' cognitive skills with regard to four content areas (geology, biology, physics and chemistry).

Colley and Davey used two instruments to conduct their study; Structure of Observed Learning Outcome (SOLO), and Superitem. SOLO is a model of evaluation which enables a child's answer to a particular question to be classified by the way in which it is structured.

The Superitem created by Cureton in 1965, is a test item in which sets of questions are asked about a particular problem situation. Each group of four questions was devised so that they formed a hierarchy of difficulty levels. Nineteen of the items were finally accepted as meeting the initial criteria. These items were arranged for group testing to enable a validation trial to be carried out. Both the Superitem and the SOLO technique use students' written answers for assesment. Collis and Davey believe that the items have construct validity and that the test has a high level of internal consistency.

4.3.4. Interview Instruments

Interviews have been used as an instrument for cognitive and attitude measurement. Osborne and Gilbert (1980) used interview techniques to investigate concept understanding in science. They interviewed students about the potential and limitations of technology in relation to the concepts of "work" and "electric current". The researchers presented different instances/examples in order to test students' understanding of general concepts.

Osborne and Gilbert believe that the potentials for the interview method include:

- applicability over a wide age-range;
- advantages over written answers e.g. the subjects cannot ignore a question or simply guess (thus testing the commitment of a student to a view);
- advantages over merely asking a student for a definition.

The limitations of the method include:

- the limited choice of specific instances;
- the order of presentation can, in certain cases, influence the answers given by students;
- the conduct of interviews must encourage dialogue and avoid the interview from turning into an oral examination;
- the interview must be conducted without cuing and giving information that will bias a student's response.

The authors suggest that this method can be used in investigating the following:

1. egocentric view of the world;
2. the language of students;
3. retention of early intuitive ideas despite formal teaching;
4. orientation and attitudes. The use of concrete examples to supplement words such as science, physics, chemistry, biology, may provide information and insights into a person's orientation to science. This may lead to a discussion of what aspects of science (as clarified through the instances) the subject enjoys, dislikes, and so on.

The authors feel that this method has considerable potential, particularly because students do not feel that they are being assessed against an externally defined system.

Finely (1984) argues that using clinical interviews has been difficult when research questions require quantitative comparisons. The central difficulty has been to construct variables that can be used to quantify and statistically compare the results of interviews, while maintaining exactly what student conceptions are associated with each variable. Finely presents a technique for constructing variables that, he claims, overcomes this difficulty. Each proposition represented in these standard terms can be used as a variable to compare quantitatively the knowledge of students as expressed in clinical interviews.

The results of the study indicate that science educators can utilize clinical interviews for research questions that require quantitative answers. According to Finely application of the technique to clinical interview data provides fundamentally different information about students' understanding of phenomena than does a typical pencil and paper achievement test.

Finely claims that the results of the analyses of clinical interviews can provide independent or complementary descriptions of exactly what correct or incorrect propositions students use in describing and explaining natural phenomena and how these propositions are interrelated. Thus statistical analysis can provide a coherent detailed picture of the students' conceptions.

Aikenhead (1988) believes that interviews are essential in clarifying student written positions in attitude assessment. By interviewing students, Aikenhead found that ambiguous student paragraphs or "positions" could indeed be clarified. Aikenhead points out that qualitative data that are derived from interviews can help to establish a firm base from which to evaluate the validity of quantitative measures.

A number of studies have shown that interviews should be used as a supplement or a clarifying method with other instruments. Renner, Abraham and Birnie (1985) used interviews to study physics students' perceptions of the exploration phase of the learning cycle. MacDonald and Bridgstock (1982) found out through interviews that university students' images of science were relatively mild and always qualified. This result was in conflict with similar Likert-type studies of student perceptions of science.

4.3.5. VOSTS

The last instrument that will be looked at is Glen Aikenhead's VIEWS ON SCIENCE-TECHNOLOGY-SOCIETY (VOSTS). This section will examine the process of developing VOSTS. In addition, a brief comparison of VOSTS to four types of response models will be examined. Certain examples of the applicability of VOSTS and some limitations of VOSTS will conclude this section.

The Development of VOSTS Items

A VOSTS item consists of a statement followed by a number of "student positions". The subject is asked to choose one position that closely resembles their own position regarding the initial statement. The development of a VOSTS item relies heavily upon student paragraph responses and student reactions during interviews. Therefore, VOSTS is considered to be an empirically-derived multiple-choice instrument (Aikenhead, Ryan and Desautels, 1989).

There are five steps in developing the VOSTS items. In step one, the students respond to two opposing statements using a Likert-type scale. They then explain in written paragraphs their reason for their answer. In the second step the evaluator analyzes the written paragraphs and finds common arguments or views. These common arguments are called "student positions". Together, these positions form a very crude multiple choice form called mc.2. In addition, the evaluator selects one of the two statements to become the item's statement. In the next step about ten students, who did not participate in step 2, respond to the revised VOSTS statement in two ways: first by writing to a paragraph response, and then by choosing one of the student positions in mc.2. This is followed by an interview to clarify the wording of the multiple-choice items. The choices are revised and form mc.3. is developed. In step 4 another group of students work through their revised multiple-choice items talking aloud about the choices made. This leads to the polishing of the item's wording for greater precision into form mc.4. In the last step a large sample of students responds to the VOSTS item. Student positions in mc.4 which receive little or no student response and which do not provide interesting feedback, are eliminated. The final revised item is designated mc.5.

The development of VOSTS items includes all four methods (Likert-type, written paragraphs, interviews, and multiple-choice format).

Aikenhead (1988) has investigated the degree of ambiguity held by four different response models used to study student attitudes toward STS topics: Likert-type, written paragraph, semi-structured interview, and empirically developed multiple choice (VOSTS).

To test the ambiguity of these four modes of investigation, Aikenhead chose a medium-sized prairie city to conduct his study. Two high schools participated, with students populations of 400 and 800. Aikenhead used VOSTS statements to investigate the four modes of response.

Aikenhead asks what information was gained, and what was lost, in each of the four modes of student response. Each response mode, he notes, involved trade-offs. "The method that required the least amount of effort, the Likert type response, yielding the least accurate-most ambiguous-results" (p. 624). Compared with Likert-type responses, he found that argumentative paragraphs substantially clarified student beliefs. Nevertheless, ambiguity lingered at approximately the 35% to 50% level because some students tended to write incomplete or inarticulate paragraphs. In addition, student paragraphs require a fair amount of effort to analyze and categorize on a large scale.

Aikenhead found that compared with written responses, semistructured interviews enhanced the understanding of student views by clarifying many, though not all, of the ambiguities found in student paragraphs. Of all four response modes, he notes, the interview offers the most lucid and accurate data. Its limitation is simply the time needed to gather and analyzed the data.

Finally, the "student position" choices (the empirically derived, multiple-choice response mode) reduced the ambiguity down to the 15% to 20% level. According to Aikenhead, in terms of obtaining the most accurate data for the least amount of resources expended, the empirically developed, multiple-choice response mode seems to be the most efficient of all modes investigated by his study.

Application of VOSTS

In 1983, the Second International Science Study of the International Association for the Evaluation of Educational Assessment (IEA) initiated a student evaluation project in Canada (Aikenhead, 1987; Aikenhead, Fleming and Ryan, 1987; Fleming, 1987; Aikenhead, Ryan and Desautels, 1989). Because this assessment received the support of the Canadian provinces, it became possible to assess Canadian students' understanding of STS topics (along with more traditional forms of science knowledge of interest to the IEA) by surveying a large Canadian national sample. The VOSTS items were used in this national assesment. A sample of graduating students was drawn from across Canada as part of the IEA study. The sample was selected mostly on the basis of course registration.

The study showed that TV had far more influence on what students believed about science and its social, technological context than did numerous science courses (Aikenhead, 1988). Furthermore, it was discovered that high-school graduates harboured diverse and contradictory beliefs about scientific knowledge. Student paragraphs reflected a belief in certain aspects of authentic science; particularly the nature of classification schemes, the tentative nature of knowledge, and the social dimensions of knowledge from within the scientific community. On the other issues, however, students seemed to be uninformed; for instance, on the nature of scientific knowledge, on the motivations for generating knowledge, and scientific method (Aikenhead, Fleming, Ryan, 1987).

Reg Fleming (1988) used VOSTS to examine university undergraduate science students' views of the nature of the relationship between science, technology and society. Two hundred students from a chemistry department in a Canadian university responded to items on the VOSTS instrument. Based on these responses, questions were designed, and using semi-structured interviews, posed to 30 students. The interviews focused on two issues: the nature of science and the role of science in our society. The VOSTS results indicated that the science students' views are remarkably similar to those of high school graduates. The interview results show that scientific facts are the central concern when dealing with the nature of science. When dealing with the role of science in society, Fleming found that mission-oriented science clashed with pure research.

VOSTS has also been used to evaluate a specific STS program. Zoller, Ebenezer, Morley, Paras, Sandberg, West, Wolthers, and Tan (1987) used a questionnaire comprised of four representative statements from the VOSTS inventory to evaluate British Columbia's SCIENCE AND TECHNOLOGY 11. The authors posed the following questions: "Do STS courses actually work? Does the reality match expectations as far as the goals of STS education are concerned? Did the already implemented STS courses have any meaningful impact on students with respect to their views on STS related issues?" (p. 14).

The authors concluded that:

> - The ST 11 course did have an impact in the "desired" direction on the viewpoints of students concerning STS.
> - Some of the prespecified superordinate goals of ST 11 which are typical for STS courses have been attained albeit some of the related sub-goals have not been achieved.
> - A simple straightforward assessment of the key outcomes of the ST 11 course (and other similar courses) is feasible, and the data-base thus obtained is meaningful, and very useful as a basis for decision-making and future educational policy-making concerning STS courses.
> - Students' viewpoints/opinions/positions about the STS interactions and closely-related issues are (locally) contextually dependent. With respect to some STS issues they are gender dependent. Although all the students (both non ST and ST 11) are not clear about the different roles that science and technology play in society, important goals of the ST 11 course were met by ST 11 students, many of whom were described by their teachers as "non-academic".
> - The VOSTS inventory (form CDN mc. 4) is an efficient, useful instrument for assessing students' views on STS related issues. Its use for cross-cultural studies and for comparisons between STS response profiles should take into consideration that these profiles are contextually bound (p. 15).

On the other hand Aikenhead, Ryan and Desautels (1989) identify four limitations of VOSTS:

1. VOSTS is only one strategy for monitoring students' reasoned beliefs about STS topics; namely, a multiple-choice instrument.
2. The STS topics included for consideration are limited to those emphasizing student cognition rather than attitude. VOSTS focuses on the reasons that the students give to justify an opinion, their informed viewpoint, their cognitive beliefs.
3. Current VOSTS items were developed for high school students, particularly 16 and 17 year-olds. Its language level may not be appropriate for lower levels.
4. Teaching science through STS means that STS content is taught in conjunction with the normal science discipline content of facts, principles, concepts and problem solving skills.

Thus, VOSTS by itself does not assess and STS course. VOSTS assesses some of the STS objectives or goals of an STS course.

5. ISSUES ON RESEARCH

A number of issues have emerged in the literature that have attracted researchers interested in measuring science attitudes and performance in science education.

Gardner (1975) reviewed the relationships between attitudes to science and other variables under a number of broad headings: other educational variables (such as achievement and intelligence); cognitive skills; personality; sex; structural variables (such as geographic location, social-economic-stature, and home background); school variables (such as "climate" and teacher behaviour); and, curriculum and instructional variables. Gardner points out that the categories he used were convenient for reviewing purposes, but were clearly not distinct and unrelated.

This section will examine some of the categories described by Gardner such as: Cognitive skills, and Gender. Furthermore, cultural and social factors will be briefly examined. These factors will be studied as they relate to students' attitude and the goals of STS education. For example, in studying cognitive skills, the issue of gender and attitudes can be interrelated. In addition, a brief examination of a specific research method (meta-analysis) will be conducted.

5.1. Testing Cognitive Skills

In this section cognitive skills are evaluated in relation to specific science course. These cognitive skills influence the attitude of students. Research in this area falls into two categories: psychological/pedagogical research and evaluation of specific courses of learning materials. In the first category, many studies have been conducted on the relationship between attitude and cognitive abilities. The following variables have been reported to have a positive association with attitude: "scientific ability" (Hodson and Freeman, 1983), scores on a Piagetian task (Lawson, Nordlan and De Vito, 1975). The following variables, on the other hand, have been reported to have a weak or no association: verbal reasoning (Hadden and Johnstone, 1982); and creativity (Starr and Nicholl, 1975). The following studies involve evaluating cognitive skills and attitudes in the context of specific learning situations. An instrument was developed by Texley and Norman (1984) to assess the logical reasoning capacity of adolescents in the content of environmental science. The researchers used a combination of clinical interviews and multiple-choice group test. The study indicates a number of findings such as:

1. the establishment of an acceptable level of validity for the instrument;
2. reasoning level of the subjects was below the theoretical levels predicted for them by theory;
3. reasoning ability in environmental science was lower than in areas associated with the physical concepts usually tested.

Hamrik and Harty (1987), in the U. S., examined the influence of resequencing general science content on 6th grade students' science achievement, attitudes toward science, and interest in science. The order of text book chapters in a general science course was changed and presented to a group of students. The resequencing was designed to clarify content structure and establish interrelationships among major concepts. A control group of students were presented with the original chapter sequence.

It was found that the students for whom content structured was clarified through resequencing the chapters exhibited significantly higher science achievement, significantly greater interest in science than students for whom general science content was not resequenced.

The study utilized two instruments: the Iowa Test of Basic Skills and the Children's Attitudes toward Science Survey. The Iowa Test of Basic Skills is a multiple-choice instrument designed in 1982 by Hiernymus, Lindquist and Hoover to measure science achievement. The Children's Attitudes toward Science Survey is a Likert-type instrument developed by Harty, Anderson and Enochs (1984) to assess students' attitudes toward science.

The results showed that learning and retaining through the presence of more inclusive, anchoring ideas in the learners structure of knowledge was achieved through resequencing content. Furthermore, new knowledge anchored or subsumed into concepts already in place, relates to other information so it is more meaningful. This study is an example of evaluating a specific teaching technique.

M. Denny (1986) in England, measured students attitudes toward science practicals. The study examined whether students see laboratory work as relevant to their everyday life. Denny used three divergent instruments: questionnaires, letter writing and drawing assignment. The author states that one problem with the questionnaire was that it was unclear to what extent pupils' responses were made on the basis of "what is" as against on the basis of "what ought to be". Perhaps another questionnaire can separate these two categories; thereby achieving increased validity.

The result of the study indicated that students consider science practical work to be useful only in the school context. Teachers' ideas about practical work were found to be similar to the students.

The views propagated by the Nuffield project in Great Britain and subscribed to by many science teachers, suggest that the value of science practical work to pupils lies in their involvement in personal discovery, in learning about the "scientific method, in developing a sense of curiosity, and in acquiring confidence in devising strategies for problem solving or learning social co-operation through group work. However instead of striving for the aims propagated by the Nuffield project, the study showed that students associated practical work with:

1. development of manipulative skills,
2. relieving boredom and generating interest, and
3. discovering new things and testing ideas.

5.2 Gender

Gardner (1975) began his review of the influence of gender on attitudes by stating: "Sex is probably the single most important variable related to pupils' attitudes to science" (p. 22). Studies which have reported that males have more positive attitudes to science than females include: Ato and Wilkson (1983); Johnson (1981); and Menis (1983). Other studies, however, have reported no statistically significant sex differences in attitudes to science; Selim and Shrigley (1983); and Wareing (1981).

A factor which needs to be considered is the posibility that sex alone is not a significant influence on student attitudes. The following studies have been conducted with regard to sex and attitude toward science.

In comparing male and female students, Dale Baker (1985) in the U. S., correlated the factors of attitude toward science, spatial ability, mathematical ability, and the scientific personality, as measured by the Myers-Briggs Type Indicator (MBTI). MBTI is based on Jung's typologies of personality. The scale descriptors are described in detail in Baker's article. The author chose MBTI because it has been widely used to assess the scientific personality and has reported reliability for a junior high school sample. The scientific personality as measured by the MBTI would be introverted (I), intuitive (N), thinking (T), and Judging (J).

Spatial ability was assessed by S2, Cube comparisons, from the Kit of Factor Referenced Cognitive Tests (1976). Attitude was assessed by the SAI.

The results showed that males and females with science grades of A and B were found to have several characteristics of the scientific personality, good grades in mathematics, but negative attitudes toward science. Males and females with science grades of C and D had a more positive attitude toward science, but poor mathematical and spatial abilities and few characteristics of the scientific personality. There were no sex differences except on the Thinking/Feeling (TF) scale of the MBTI. As expected by the author, females portrayed themselves as preferring the (F) scale, the use of personal values when making decisions. Males portrayed themselves as preferring the (T) scale, the use of logical analysis when making decisions.

A study by Linn (1987), in the U. S., explores gender differences by using the National Assessment of Educational Progress Science Items (1987). The NAEPS items differ from many science knowledge tests in that they allow respondents to choose "I don't know" rather than guessing or leaving items blank. The NAEPS is comprised of four booklets. The researcher constructed a "test" out of the cognitive items in each booklet. A total score on the test consisting of the number of correct responses was calculated for each respondent.

The author found that significantly more females than males chose the "I don't know" answer. The author considered the possibility that the way students felt about science, might be a factor in their acceptance of uncertainty when choosing responses. To test this possibility, she used science attitude scales administered as a part of booklet four. Attitudes toward science were measured in four categories:

- liking of science
- attitudes toward science teachers
- usefulness of science
- participation in informal science activities.

The author found that science attitudes neither accounted for any substantial variation in total score in booklet four; nor differentiated between the sexes. She believes rather than cultural background, societal factors and psychological factors are responsible for the high female response to the "I don't know" answer.

The results explained the gender differences in choosing of the "I don't know" item by students as:

1. differential prior instructions,
2. differential response to uncertainty and the use of "I don't know" response,
3. differential response to "figurally" presented items,
4. different attitudes toward science.

Linn stresses that females were more likely to use "I don't know" for such items with physical science or masculine themes such as football. The author feels that to ameliorate this situation there is need for more effective science instruction and more gender neutral assessment items.

A study conducted by Erb and Smith (1984) measured the validity of adolescent males and females' attitude toward women in science. The researchers used Women in Science Scale (WISS).

WISS is a 27 item Likert-type instrument. The 6 point WISS scale ranges from "strongly agree" to "strongly disagree" with no neutral point. The importance of three dimensions of attitude toward women in science were used in the WISS: characteristics needed for science career pursuit; compatability of spouse, parent, and career roles; and equality of opportunity to pursue a career. The WISS was developed to evaluate COMETS (Career Oriented Modules to Explore Topics in Science). COMETS is a set of curriculum materials for grades 5 through 9. It is designed to enable science teachers to confront students with role models of women in science careers. It is a technique which had been shown to be a successful avenue for encouraging more girls to consider pursuit of science careers. The validity of WISS has been established by showing that it clearly distinguishes between scores of early adolescent males and females regardless of age or their construct of interest.

WISS can be useful to evaluate a science career education program for early adolescents and to evaluate similar programs intended to effect attitudes toward women in science among both males and females in middle school/junior high. It can also be used to compare the attitudes toward women in science held by different groups of early adolescents. The subjects were differentiated by sex, race, socioeconomic status, grade levels, and locale (urban vs. rural).

In Ontario (Connelly, 1987) it was found that in evaluating science achievement, males were better than females; but not by so much as evaluators thought they might be. The instrument used a three point scale: "agree", "uncertain", and "disagree". Connelly argues that our own culture limits our ability to sort out the "genetic", "environmental" and "educational" differences. The ideas of achievement are restricted by the kinds of knowledge and the "ways of knowing" which are socially valued and tested. The differences in boys' and girls' achievement may simply reflect the differences in the way society has valued particular ways of knowing over others.

5.3. Culture

In evaluating STS courses or attitudes toward science, cultural differences must be taken into account. A number of researchers have concluded that evaluation instruments are culturally restricted (Khalili, 1987; Hofstein, Scherz and Yager, 1986; Zoller, 1987).

Zoller attempted a comparison of B. C. students' STS response profile, with that of American students. He found the comparison nearly impossible due to the different design, target populations, methodology, and purpose of the two studies. However, in probing into this issue through quasi-quantitative meta-analysis methodology, Zoller points out that the base line STS response profile of the two populations is significantly different.

According to Zoller this is to be expected, since "STS issues" are contextually bound; that is, perception by the public is contingent on the particular local socio-cultural norms and realism of economic/political constraints.

In designing STS science courses, the cultural background of the students must be taken into consideration. According to Smith (1986), native students in Manitoba have different needs that non-native students. Smith provides an analysis of work being done with native children in Manitoba to help them learn about the connections between myths and beliefs of their own culture and the science taught in school. Smith explores the theoretical perspective and practical examples of how this integration can occur.

For example, Smith points out that native students have well developed observational skills. However, due to language and past experiences, they might state their observations differently than expected in the classroom. Furthermore, Smith stresses, curriculum and test development must take into consideration the cultural differences for native students.

As mentioned above, students' cultural background is a factor in curriculum development and evaluation. An interesting study conducted by Quinn and Kessler (1986) examines the scientific abilities of unilingual and bilingual adolescents, in south-western United States. The subjects were 6th grade students in two intact classrooms, one unilingual English speaking and one Spanish-English bilingual. Twelve science inquiry film sessions and six discussion sessions were used. All lessons were taught by the same teacher in English. Each film session based on a 3-minute film loop depicting a single physical science problem, ended with the students writing as many hypotheses as possible in a rigorously controlled 12-minute period.

Quinn and Kessler compared the ability of unilinguals and bilinguals to formulate scientific hypotheses; to write syntactically more complex language; and to generate multiple metaphors.

The researchers believe that the ability to use science processes is a manifestation of cognition. They claim that bilingualism enhances that ability in at least one of its aspects. While an aspect of cognitive ability is language development, the metaphorizing process is more apparent for bilinguals engaged in the process of formulating solutions to scientific problems than for unilinguals.

The results of the study demonstrated that bilingualism appears to have a positive effect on the cognitive ability of students to formulate science hypotheses and to use language of increasing complexity. Bilinguals are also more capable of entering into the creative processes of divergent and convergent thinking. The generation of multiple solutions to science problems and hypotheses formulation are expressions of divergent thinking and a form of creativity.

Quinn and Kessler feel that the enrichment that appears to accompany bilingualism is intimately related to the cultural universe or experimental domains of the students. The cultural background of the Mexican-American children in this study appears to effect the way they formulated scientific hypotheses in the creative, metaphoric use of language. The authors believe that a science education program which would require more precise, analytical language prematurely, would fail for these children to take into account cultural diversity and its contributions to creativity in language cognitive functioning.

It must be mentioned that the above benefits of bilingualism would only occur if the subject is completely fluent in both languages. Otherwise, the subject would not be able to comprehend the complexity of the science topic. This study could be relevant to Canadian researchers exploring the multicultural facet of science education. In addition it must be noted that certain instruments of evaluation are culturally relevant to the subjects. Cultural differences between students and science teachers can also influence learning of the subject.

5.4. Social Influence/pressures

In studying attitudes, researchers have found that societal factors affect students' behaviour in science classes. A study of decision-making theories as tools for interpreting student behaviour during a scientific inquiry was conducted by Glen Aikenhead (1989). In this experiment students attempt to resolve conceptual conflicts concerning a pendulum's period by working towards a consensus. Aikenhead studied factors that affect conceptual changes in classroom decision-making. In particular he analyzed strategies students invented to maintain their alternative conceptions of motion related to the pendulum in the face of conflicting evidence.

Aikenhead questions the degree that decision-making models accurately portray what students do when engaged in classroom decision-making. The results of his study show that conflict exists between sticking to one's biases and believing the science instruction. According to Aikenhead, if a sociological theory could be refined in the simpler context of students making scientific decisions, then the theory may be applied to the context of students making the socio-scientific decisions found in STS instructions. In the STS context, students are expected to deal with both nonsocial cognition and social cognition.

Therefore, Aikenhead believes that decision-making models from sociology and psychology are of little use in predicting the more complex decisions associated with socio-scientific issues. Aikenhead stresses that scientists do not necessarily change their conceptions solely on the basis of new evidence and its explanation. Rather scientists often demonstrate a commitment to their conceptions. The same can be expected of students. Thus, decision can be swayed by: authority of data, authority of explanation, making sense out of the data, authority of teacher, the class social environment, psychological state of decision maker. Since decision-making is a part of the STS curriculum, this study is relevant in designing STS programs.

The role of the media in students' attitude toward science has been studied by Schibeci (1986). Schibeci is concerned with the portrayal of science and scientists in popular culture. Schibeci points out that literature and the media represent one of the many informal avenues for science education, along with museums, fairs, and exhibits. Of these, television appears to be potentially the most powerful of these informal avenues because children watch so much of it. Thus in assessing students attitude toward science, it should be remembered that outside influences (such as TV) are a factor in attitudes.

5.5. Meta-analysis as a Research Tool

Meta-analysis uses a quantitative approach. It is described by its originator as "the statistical analysis of the summary findings of many empirical studies" (Glass 1982, p. 200). This approach to the integration of the research literature has been rejected by some (Haig, 1988). Others such as Strube and Hartmann (1982), indicate the potential usefulness of the approach, provided its limitations are recognised.

According to Schibeci (1984, p. 29), one line of investigation which could be pursued by those interested in meta-analysis would be a reliability trial. Two people (or two groups of people) would conduct, quite independently, the meta-analysis of the same broad area of concern. The results could then be compared. Schibeci notes that another, perhaps more important line of investigation, would be to examine the validity of the method- to what extent are the assumptions which underlie the method valid? Another note of caution which needs to be sounded is the ease with which the results of meta-analysis can be misinterpreted.

6. CONCLUSION

The incorporation of STS in science education at the secondary level is growing rapidly. As new programs come on stream, evaluators will continue to address the concerns and interests reviewed in this report. While this review cannot pretend to be comprehensive, since the field is so varied and changing, a number of summary conclusions can be drawn that are relevant to the Ontario context.

6.1. Diverseness of STS

The nature and role of STS in science education means different things to different people. Some science educators and curriculum developers see STS as a motivator, and secondary to science content. Others view STS as providing critical thinking and social skills. There is often tension between science teachers holding these different views. Science teachers that see STS as a motivator rather than the focus of a science course believe that science should be taught as method of knowing. On the other hand, there are teachers that see science as a social institution and they think it should be taught as such. This conflict has to be kept in mind while developing science curricula as well as evaluation instruments. It should certainly be borne in mind when interpreting results from evaluation or monitoring instruments.

There also exist opposing views regarding the relationship between science and technology. For most STS researchers, technology is seen as an independent entity from science. However, many educators (including the Ontario Ministry of Education) see technology simply as applied science. Thus, evaluators and researchers must be wary of the different philosophies that are brought into teaching the curriculum when interpreting results of evaluations. This is specially relevant, since students receive information and form opinions from material obtained outside the classroom.

6.2. Culture

Cultural diversity is an important factor in science education and STS evaluation. For example an instrument developed in Australia or even the United States might not be relevant to a Canadian setting. Instruments must be sensitive to the ethnic diversity in Canadian schools.

6.3. Gender

For an STS program to be implemented effectively, it must be gender neutral. The same is true for instruments used for STS evaluation. However, the role of women in science is an important part of STS education and should not be ignored. Furthermore, the presentation of role models for female science students may encourage women to enter careers in science.

6.4. Local Relevance

STS implementation and evaluation must be locally relevant. Studies have shown that students relate better to STS issues when presented with specific examples close to home. For the Ontario context, this means that STS evaluation must reflect the various regions of the province. In addition, there should be national relevance for students as citizens of Canada.

These considerations do not preclude an international context being present in STS teaching and evaluation. As the world becomes smaller because of the technological revolution, the role of science and technology must be looked upon in its global context. For example, environmental issues that effect us regionally are also important in the international context. This dichotomy must be reflected in STS programs and evaluation.

In conclusion, it is appropriate to come back to the diverse nature of the STS field. The perception of science and technology as integral parts of the social fabric is relatively new in science education, especially at the secondary level. Alongside teachers and curriculum developers with a fairly sophisticated understanding of the role of science and technology in society, are those who hold quite positivistic views about the primacy of scientific thinking and its importance for technological and economic progress. Add to this mix the variations of culture, regional interests, training, motivation and pedagogical philosophy that characterize Ontario's teaching professionals and student body. And also consider the fact that students pick up a great deal of their information and opinions - perhaps indeed the majority - from outside sources such as television, newspapers and books. One can only conclude, therefore, that the STS component of the Ontario science curriculum will be taught by teachers and learned by students in a multiplicity of ways.

Hence one must appreciate the fact that no one instrument can possibly measure all the subtleties of students' understanding of STS issues. The best attempts will undoubtedly be made to develop monitoring and evaluation instruments that are gender neutral, sensitive to cultural diversity and inclusive of various views regarding the nature and importance of science and technology. However, interpreters of the data must bear in mind the variations that exist in the STS field itself, and the teaching and learning environments in which it is taught and learned.

The best use of data obtained from an instrument of a pool of questions that are used to measure students' views on STS, is to establish a baseline from which to monitor progressive change.

7. FOOTNOTES

1. There are also summations of these reports in McConnell's article: national science foundation status of science education studies, national science foundation and department of education joint report on science and engineering education (1980), status study of graduate science education in the united states 1960-1980, the advisory committee for science education of the national science foundation's report to the national science board (1980).

8. BIBLIOGRAPHY

Adeniyi E. O., "Curriculum Development and the Concept of Integration in Science - Some Implications for General Education", Science Education (Vol. 71, 1987).

Aikenhead G. S., "Decision-Making Theories as Tools for Interpreting Student Behaviour During a Scientific Inquiry Simulation. Journal of Research in Science Teaching (Vol. 25, 1989).

———, "An Analysis of Four Ways of Assessing Student Beliefs About STS Topics, Journal of Research in Science Teaching (Vol. 25, 1988).

———, "High School Graduates' Beliefs about STS III. Characteristics and Limitations of Scientific Knowledge", Science Education (Vol. 71, 1987).

———, "Course Evaluation I: A New Methodology for Test Construction on Evaluative Tests", Journal of Research in Science Teaching (Vol. 11, 1974).

———, "Course Evaluation: The Construction and Interpretation of Tests", Saskatchewan Journal of Educational Research and Development (Vol. 4, 1973).

———, "The Measurement of High School Students' Knowledge about Science and Scientists". Science Education (Vol. 57, No. 4, 1973).

———, Fleming R. W. and Ryan A. G., "High School Graduates Beliefs about STS. I. Methods and Issues in Monitoring Student Views", Science Education, (Vol. 72, 1987).

—————, Science: A Way of Knowing, Saskatoon: Department of Curriculum Studies, University of Saskatchewan, 1975.

———, Ryan A. G. and Desautels Jacques, "Monitoring Student Views on Science-Technology-Society Topics: The Development of Multiple-Choice Items", A paper presented to the annual meeting of the National Association for Research in Science Teaching, San Francisco, April 1, 1989.

American Association for the Advancement of Science, EVIST, resource directory. Washington D. C.: American Association for the Advancement of Science, 1978.

Ato, T and Wilkinson, W., "Factors Related to Secondary School Students' Attitudes to Science in Benue State of Nigeria", Research in Science and Technological Education (Vol. 1, 1983).

Baird W. E. and Borich G. D. "Validity Considerations for Research on Integrated Science Process Skills and Formal Reasoning Ability", Science Education (Vol.71, 1987).

Erb T. O. and Smith W. S. "Validation for the Attitude toward Women in Science Scale for Early Adolescents (WISS)" Journal of Research in Science Teaching (Vol. 21, 1984).

———, "Comments on the Development of the Image of Science and Scientists Scale", Journal of Research in Science Teaching (Vol. 20, 1983).

Farrell M. A. and Farmer W. A., "Adolescents Performance on a Sequence of Proportional Reasoning Tasks", Journal of Research in Science Teaching (Vol. 22, 1985).

Fensham Peter, "Approaches to the Teaching of STS in Science Education", International Journal of Science Education (Vol. 10, 1988).

Finley F. N., "Using Propositions from Clinical Interviews as Variables to Compare Student Knowledge", Journal of Research in Science Teaching (Vol. 21, 1984).

Finson K. D. and Enochs L. G., "Students Attitudes Toward STS Resulting from Visitation to a Science-Technology Museum", Journal of Research in Science Teaching (Vol. 24, 1987).

Fleming Reg, "High School Graduates' Beliefs About STS. II. The Interaction Among Science, Technology, and Society". Science Education (Vol. 71, 1987).

———, Undergraduate Science Students' Views on the Relationship between Science, Technology and Society", International Journal of Science Education (Vol. 10, 1988).

Gallagher James, and Dawson George eds., Science Education and Cultural Environments in the Americas: A Report of an Inter-American Seminar on Science Education (Panama City: National Science Teachers Associations, 1986).

Gardner P. L., "Measuring Ambivalence to Science", Journal of Research in Science Teaching (Vol. 24, 1987).

———, "Attitudes to Science: A Review", Studies in Science Education (Vol. 2, 1975).

Gaskell James, "Science Education for Citizens: Perspectives and Issues. I. Science, Technology and Society: Issues for Science Teachers", Studies in Science Education (Vol. 9, 1982).

GCE 0-level and CSE Examinations: SCIENCE, TECHNOLOGY AND SOCIETY, (Northern Examining Association, 1987).

Germann P. J., Development of the Attitude toward Science in School Assessment and its Use to Investigate the Relationship between Science Achievement and Attitude Toward Science in School", Journal of Research in Science Teaching (Vol. 25, 1988).

Glass, G. V. "Meta-analysis: An Approach to the Synthesis of Research Results", Journal of Research in Science Teaching (Vol. 19, 1982).

Good R., Herron D., Lawson A. and Renner J., "The Domain of Science Education", Science Education (Vol. 69, 1985).

Hadden, R. A. and Johnstone A. H., "Primary School Pupils' Attitudes to Science: The Years of Formation", European Journal of Science Education (Vol. 4, 1982).

Haig B. D., "Meta-Analysis: An Inappropriate Rationale for Science Education Research", Journal of Research in Science Teaching (Vol.25, 1988).

Hamrick L. and Harty H., "Influence of Resequencing General Science Content on the Science Achievement, Attitudes toward Science, and Interest in Science of Sixth Grade Students", Journal of Research in Science Teaching (Vol. 24, 1987).

Harms, N. S. and Yager, R. C. What Research Says to the Science Teacher, (Washington D. C.: National Science Teachers Association, 1981).

Harty H. and Beale D., "Toward the Development of a Children's Science Curiosity Measure", Journal of Research in Science Teaching (Vol. 21, 1984).

Hawkins J. and Pea R. D., "Tools for Bridging the Cultures of Everyday and Scientific Thinking", Journal of Research in Science Teaching (Vol. 24, 1987).

Hazelwood R. D., "Extremism in Response to Questionnaires and its Relationship to Ability", Educational Research (Vol. 31, 1989).

Hills George, "Students 'Untutored' Beliefs about Natural Phenomena: Primitive Science or Commonsense", Science Education (Vol. 73, 1989).

Hodson Derek, "Philosophy of Science, Science and Science Education". Studies in Science Education (Vol. 12, 1985).

———, "The Effects of Changes in Item Sequence on Student Performance in a Multiple Choice Chemistry Test" Journal of Research in Science Teaching (Vol. 21, 1984).

———, and Freeman P. "The Effect of Primary Science on Interest in Science: Some Research Problems", Research in Science and Technological Education (Vol. 1, 1983).

Hofstein A. Scherz Z. and Yager R. E., "What Students Say About Science Teaching, Science Teachers and Science Classes in Israel and the United States", Science Education (Vol. 70, 1986).

———, and Mandler V. "The Use of Lawson's Test of Formal Reasoning in the Israeli Science Education Context", Journal of Research in Science Teaching (Vol. 22, 1985). Discussion: Vol. 24, 683-6, 1987.

———, "Future Trends in Integrated Science in Relation to Technological Studies" in New Trends in Integrated Science Teaching Vol.5 (Paris: UNESCO, 1979).

———, Aikenhead Glen, and Riquarts Kurt, "Discussions over STS at the Fourth IOSTE Symposium, International Journal of Science Education (Vol. 10, 1988).

———, Yager Robert, "Societal Issues as Organizers for Science Education in the 1980s", School Science and Mathematics (Vol. 7, 1982).

Holden C. C. and Barrow L. H. "Validation of the Test of Energy Concepts and Values for High School", Journal of Research in Science Teaching (Vol. 21, 1984).

Hunt Andrew, "SATIS Approaches to STS", International Journal of Science Education (Vol. 10, 1988).

Hurd Paul, "Transformation of Science Education: Challenges and Criteria", Science Education (Vol. 73, 1989).

———, "Perspectives for the Reform of Science Education", Phi Delta Kappan, January, 1986.

———, "Integrated Science", Science Teacher (N. 40, February, 1973).

———, "The Scientific Enlightenment for an Age of Science", Science Teacher (Vol. 37, January 1970).

Jegede O., "The Development of the Science, Technology and Society Curricula in Nigeria", International Journal of Science Education (Vol. 10, 1988).

Johnson R. T., "Children's Attitudes toward Science" Science and Children (Vol. 18, 1981).

Khalili D. Y., "A Cross Cultural Validation of a Test of Science Related Attitudes", Journal for Research in Science Teaching (Vol. 24, 1987).

Krumhout Robert and Good Ron, "Beware of Societal Issues as Organizers for Science Education", School Science and Mathematics (Vol. 83, 1983).

Larkin J. H. and Rainard B., "A Research Methodology for Studying How People Think" Journal of Research in Science Teaching (Vol. 21, 1984). Discussion 23: 849-52.

Lawson, A. E., Nordland, F. G. and DeVito, A., "Relation of Formal Reasoning to Achievement, Aptitudes, and Attitudes in Preservice Teachers", Journal of Research in Science Teaching (Vol. 12, 1975).

Layton David, "Revaluing the T in STS", International Journal of Science Education (Vol. 10, 1988).

Lewis J. L. and Kelly P. J. eds., Science and Technological Education and Future Human Needs, (Oxford: Pergamon Press, 1987).

Linn, M. C. et al "Gender Differences in National Assessment of Educational Progress Science Items: What does "I don't know" really mean? Journal of Research in Science Teaching (Vol. 24, 1987).

Manzelli P., "Science, Society and Trends in Science Education: Some Thoughts on the Development of Integrated Science in the Educational Systems of the World", European Journal of Science Education (Vol. 2, 1980).

MacDonald, D. and Bridgstock, M., "Students Views of Science and Scientists", Australian Science Teachers Journal (Vol. 28, 1982).

McConnell Mary, "Teaching about Science, Technology and Society at the Secondary School Level in the United States. An Educational Dilemma for the 1980s", Students in Science Education (Vol. 9, 1982).

McFadden C. P. ed., World Trends in Science Education (Nova Scotia: Atlantic Institute of Education, 1980).

McKenzie D. L. and Padilla M. J., "The Construction and Validation of the Test of Graphing in Science (TOGS)", Journal in Research in Science Teaching (Vol. 23, 1986).

Miller Robin and Wynne Brian, "Public Understanding of Science: From Contents to Processes", International Journal of Science Education, (Vol. 10, 1988).

Menis, J., "Attitudes towards Chemistry as Compared with Those towards Mathematics, Among Tenth Grade Pupils (Aged 15) in High Level Secondary Schools in Israel", Research in Science and Technological Education (Vol. 1, 1983).

Mitchener C. P. and Anderson R. D., "Teachers' Perspective: Developing and Implementing an STS Curriculum", Journal of Research in Science Teaching (Vol. 26, 1989).

Moore R. and Sutman R., "The Development, Field Test and Validation of an Inventory of Scientific Attitudes", Journal of Research in Science Teaching (Vol. 7, 1970).

Morgenstern C. F., "Measuring Thinking with Standarized Science Test", Journal of Research in Science Teaching (Vol. 21, 1984).

Munby H., "Thirty Studies Involving the "Scientific Attitude Instrument". What Confidence Can We Have in Their Instrument?" Journal of Research in Science Teaching (Vol. 20, 1983).

———, "The Impropriety of "Panel Judges" Validation in Science Attitude Scales: A Research Comment", Journal of Research in Science Teaching (Vol. 19, 1982).

Orpwood Graham and Souque Jean-Pascal, Science Education in Canadian Schools, Volume I. Introduction and Curriculum Analyzes, (Ottawa: Science Council of Canada, 1984).

———, and Alam Isme, Science Education in Canadian Schools, Volume II. Statistical Database for Canadian Science Education, (Ottawa: Science Council of Canada, 1984).

Osborne R. J. and Gilbert J. K., "A Method for Investigating Concept Understanding in Science" European Journal of Science Education (Vol. 2, 1980).

Ogawa M., "Toward a New Rationale of Science Education in a Non-Western Society", European Journal of Science Education (Vol. 8, 1986).

Page James, A Canadian Context for Science Education, Ottawa: Science Council of Canada, 1979.

Penick J. E. and Yager R. E., "Trends in Science Education: Some Observations of Exemplary Programmes in the United States", European Journal of Science Education (Vol. 8, 1986).

Quinn Mary and Kessler Carolyn, "Bilingual Children's Cognition and Language in Science Learning", Science Education and Cultural Environments in the Americas: A Report of Inter-American Seminar on Science Education, eds, James Gallager and George Dawson, (Panama City: National Science Teachers Association, 1986).

Renner J. W., Abraham M. R. and Birnie H. H., "The Importance of the Form of Student Acquisition of Data in Physics Learning Cycles", Journal of Research in Science Teaching (Vol. 22, 1985).

Roberts D. A., Mc. Leod P. E. and Orpwood G. W., Separation of Substances, Toronto: Ontario Institute for Studies in Education Press, 1981.

Rugumayo E. B., "Science Education and the Needs of Developing Countries", Science and Technological Education and Future Human Needs eds, J. L. Lewis and P. J. Kelly (Oxford: Pergamon Press, 1987).

Science Education in Canadian Schools. Volume III. Case Studies of Science Teaching (Ottawa: Science Council of Canada, 1984).

Science for Every Student, Educating Canadians for Tomorrow's World, (Hull, Quebec: Science Council of Canada, 1984).

Science and Technology 11, Curriculum Guide 1986, Province of British Columbia, Ministry of Education (Curriculum Development Branch, 1986).

Schibeci R. A., "Attitudes to Science: An Update", Studies in Science Education (Vol. 11, 1984).

———, "Images of Science and Scientists and Science Education", Science Education (Vol. 70, 1986).

Selim, M. A. and Shrigley, R. L. "The Group-Dynamics Approach: A Socio-psychological Approach for Testing the Effect of Discovery and Expository Teaching on the Science Achievement and Attitude of Young Egyptian Students". Journal of Research in Science Teaching (Vol. 20, 1983).

Shrigley, R. L. and Koballa T. R., "Attitude Measurement. Judging the Emotional Intensity of Likert-Type Science Attitude Statements", Journal of Research in Science Teaching (Vol. 21, 1984).

Smith Murry, "A Model for Teaching Nature Oriented Science", Science Education and Cultural Environments in the Americas: A Report of Inter-American Seminar on Science Education, eds, Gallager and Dawson, (Panama City: National Science Teachers Associations,1986).

Solomon Joan, "Science Technology and Society Courses: Tools for Thinking About Social Issues", International Journal of Science Education (Vol. 10, 1988).

Starr, J. W. and Nicholl, C., "Creativity and Achievement in Nuffield Physics", British Journal of Educational Psychology" (Vol. 45, 1975).

Stronck D. R., "Teachers Attitudes Toward Science Coordination in B. C.'s School Districts", Science Education (Vol. 71, 1987).

Texley J. T. and Norman J. "The Development of a Group Test of Formal Operational Logic in the Content Area of Environmental Science", Journal of Research in Science Teaching, (Vol. 21, 1984).

Tobin K. G. and Capie W., "Development and Validation of a Group Test of Integrated Science Processes", Journal of Research in Science Teaching (Vol. 19, 1982).

Treagust David, "Development and Use of Diagnostic Tests to Evaluate Students' Misconceptions in Science", International Journal of Science Education (Vol. 10, 1988).

Vargas-Gomez R. G. and Yager R. E., "Attitude of Students in Exemplary Programs toward Their Science Teachers", Journal of Research in Science Teaching (Vol. 24, 1987).

Wanchoo V. N. ed., World Views on Science Education, (New Delhi: Oxford and IBH Publishing Co., 1982).

Wareing, C. "Cognitive Style and Developing Scientific Attitudes in the SCIS Classroom", Journal of Research in Science Teaching (Vol. 18, 1981).

Waring M., Social Pressures and Curriculum Innovation: A Study of the Nuffield Foundation Science Teaching Project, (London: Methuen and Co. Ltd., 1979).

Yager R. E. and McCormack, "Assessing Teaching/Learning Successes in Multiple Domains of Science and Science Education", Science Education (Vol. 73, 1989).

———, and Penick J. E., "Changes in Perceived Attitudes towards the Goals for Science Instruction in Schools", Journal of Research in Science Teaching (Vol. 25, 1988).

————————, "Perceptions of 4 age groups toward Science Classes, Teachers and the Value of Science", Science Education (Vol. 70, 1986).

———, "Searching for Excellence", Journal of Research in Science Teaching (Vol. 23, 1986).

———, "Defining the Discipline of Science Education", Science Education (Vol. 68, 1984).

———, "In Defence of Social Issues as Organizers for Science Education in the 1980s", School Science and Mathematics (Vol. 83, 1983).

Za'rour G. I. "Adapting Science and Technology Education to a Changing Society and to the Diversity of Needs of Arab States", European Journal of Science Education (Vol. 3, 1981).

Ziman J., Teaching and Learning about Science and Society, (Cambridge: Cambridge University Press, 1980).

Zoller Uri, Ebenezer J., Morley K., Paras S., Sandberg V, West C, Wolthers T., and Tan S. H., "Goals' Attainment in Science-Technology-Society (STS) Education: Expectations and Reality. A Probe into the Case of British Columbia", Unpublished Draft, 1987, Courtesy of Glen Aikenhead.

APPENDIX "A"

FINAL TEST INSTRUMENT USED
IN PROVINCE-WIDE TEST
MARCH-APRIL 1990

ONTARIO SCIENCE AND TECHNOLOGY SURVEY #B483
conducted by
MARKET FACTS OF CANADA LIMITED

Market Facts of Canada Limited
77 Bloor West, Toronto M5S 3A4
(416) 964-6262

Thank you very much for taking part in this survey among students in Ontario. The main purpose of this study is to find out how the present generation of high school students like yourself feel about matters related to science and technology.

In any effort to understand what science and technology mean to Canadians, the views of students are particularly important. You in fact represent Canada's future and your feelings today will influence attitudes towards various issues (like science and technology) in the years to come.

Please give us your opinion on each of the subjects in the questionnaire. There is no identification required. You are therefore assured of complete anonymity.

Please put your completed questionnaire in the envelope provided and seal it before handing it in. All envelopes will be opened and the questionnaires tabulated by Market Facts of Canada Limited to ensure the anonymity of those taking part in the survey.

INSTRUCTIONS FOR COMPLETING QUESTIONNAIRE

This questionnaire is made up of two parts. As you can see the first part is divided into a number of individual boxes, each containing 3 or 4 sentences.

Each box deals with one aspect of science and technology and the sentences in the box express different ideas or opinions on this. FOR EACH BOX, please read all the sentences and then circle the number next to the one that comes closest to your opinion.

In the lower half of each box, space has been provided for you to write in your feelings on the subject.

Before you go on to answer the questionnaire please complete the section below. This information is needed for tabulation only.

- -

Cd. 1

AGE in years ☐☐ 6- 7-

SEX: Male ..... ☐1 -8
Female ... ☐2

GRADE/LEVEL:
Grade 10 Basic Science ...... ☐ 1 -9
Grade 10 General Science ... ☐ 2
Grade 10 Advanced Science . ☐ 3
Grade 12 Basic Science ...... ☐ 4
Grade 12 General Science ... ☐ 5
Grade 12 Advanced Science . ☐ 6

10 bl.

Name of school: ____ -11

Type of school: Public ☐1 Parochial ☐2

City/town in which located: ____ 12- 13-

14-1
15-1

16-19 bl.

1. -20

Science is explaining the unknown. 1

Science is using what we know to make the world a better place to live in. 2

Science is subjects like chemistry, physics and biology. 3

Science is a group of people (scientists) and what they believe. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

2. -21

Technology is how science is put to use. 1

Technology is using what we know to make the world a better place to live in. 2

Technology is machines and inventions. 3

Technology is machines and inventions as well as designing things. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

3. -22

Scientists and engineers should decide what types of energy (such as nuclear, hydro, solar etc.) Canada will use in the future, because they know best. 1

Everybody should be involved in deciding what types of energy Canada will use in the future, because we are all affected by the decision. 2

People other than scientists and engineers should decide what types of energy Canada will use in the future, because the decision is a social and economic one, not a technical one. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

4. -23

We have to accept both the good and the bad effects of technology, because every new development has at least one bad effect, and to enjoy the good ones we have to put up with the bad ones. 1

We don't have to accept the bad effects of technology, because bad effects can be reduced or removed through careful planning and testing. 2

We don't have to accept the bad effects of technology, because some new developments have no bad effects and we should use those ones only. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

5. -24

Science and technology will not be able to solve problems caused by pollution, because the problems are so bad that it would cost too much. 1

Science and technology alone cannot solve problems caused by pollution. 2

Science and technology can solve problems caused by pollution, because science and technology have been successful in solving problems in the past. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

6. -25

Women scientists might make different discoveries from those made by men scientists, because women have different feelings and experiences from men. 1

Women scientists and men scientists are all scientists, so they make the same kind of discoveries. 2

Different discoveries made by different scientists have nothing to do with whether the scientists are men or women. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

BEST COPY AVAILABLE

7. -26

Science classes have helped me become a better shopper, because I can use the scientific method and/or scientific facts to help me decide which products to buy. 1

Science classes have not helped me become a better shopper. Neither the scientific method nor scientific facts can possibly help me decide which products to buy. 2

Science classes have not helped me become a better shopper. Even though science teaches the scientific method and valuable facts, people like me tend to buy things they see on television or in advertisements. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

8. -27

The mass media (television, newspapers, magazines etc.) give you a better picture of what science is really like, than science classes do. 1

Neither the mass media, nor science classes, give you a good picture of what science is really like. 2

Science classes give you a better picture of what science is really like, than the mass media do. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

9. -28

Most scientists are doing science:

- to satisfy their own curiosity about the world around them. 1
- to be well known and/or rich. 2
- because they want to help people by finding new medical cures and solutions to environmental problems and by new inventions. 3
- because they want to be looked up to by other scientists. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

10. -29

If Canada spent more money on research in science and technology, Canada would become a wealthier country. 1

If Canada spent more money on research in science and technology, Canada might or might not become a wealthier country. It would depend on what science and technology were chosen. 2

If Canada spent more money on research in science and technology, Canada might become poorer, because other ways of making Canada wealthier would suffer. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

11. -30

There are more men scientists than women scientists today:

- because boys are more interested in science than girls are. 1
- because boys are better at science than girls are. 2
- because until recently people used to believe that boys were better at science and that girls were better at other things, so more boys than girls made science their career. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

12. -31

Scientists who work for a profit-making company tend to put the company's interests ahead of doing the best science they can. 1

Scientists who work for a profit-making company put doing the best science they can ahead of the company's interests. 2

Some scientists who work for a profit-making company put doing the best science they can first; others put the company's interests first. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

BEST COPY AVAILABLE

13. -32

When scientists are deciding whether or not to accept a theory:

- **they look only at the facts. If the theory explains the facts, they accept it. If the theory cannot explain even just one fact, they do not accept the theory.** 1
- **they look at the facts and the theory. If a theory is simpler and/or more logical than other theories, they may accept it even if all the facts are not explained.** 2
- **they sometimes accept it for reasons that have nothing to do with how well it compares with other theories or how well it explains the facts.** 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

14. -33

Scientists trained in one country look at scientific problems in different ways from scientists trained in another country, because their education and way of life are different. 1

Scientists are taught to look at scientific problems in the same way, no matter what countries the scientists are from, because science is the same all over the world. 2

Any two scientists may look at scientific problems differently. The country where they come from makes no difference. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

15. -34

If a new technology will do more harm than good to society, it will not be used. 1

If a new technology works well, is efficient and doesn't cost much, it will be used even if it does more harm than good to society. 2

Most new technologies are used, because some people benefit from them, even though others may see the harm they can do. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

35-78 Bl.

79-0
80-1

BEST COPY AVAILABLE

Cd.2

Below are some pairs of opposite statements. Please read each pair, then circle the number which best describes your opinion. The closer the number is to one of the statements, the more you agree with that statement.

16-19 Bl.

Studying science has made me more interested in issues such as pollution	1	2	3	4	5	6	7	Studying science has not made me more interested in issues such as pollution	-20
Women scientists tend to be too aggressive	1	2	3	4	5	6	7	Women scientists are no more nor less aggressive than other women	-21
I'm more interested in people than in technology	1	2	3	4	5	6	7	I'm more interested in technology than in people	-22
Other people look up to scientists more than they do to, say, businesspeople	1	2	3	4	5	6	7	Other people look up to, say, businesspeople more than they do to scientists	-23
I'm glad I have had to learn at least some science	1	2	3	4	5	6	7	I wish I had never had to learn any science	-24
To improve our quality of living, Canada should spend more on technological and scientific research, than on education and welfare	1	2	3	4	5	6	7	To improve our quality of living, Canada should spend more on education and welfare, than on technological and scientific research	-25
Most scientists seem to be "absent-minded" professors	1	2	3	4	5	6	7	Most scientists seem to be just like other people	-26
I do not like all the detail that goes into learning science	1	2	3	4	5	6	7	I love all the detail that goes into learning science	-27
Government agencies should be the ones to tell scientists what to do research on	1	2	3	4	5	6	7	Scientists themselves should be the ones to decide what to do research on	-28
I would like to study technology at a university after high school	1	2	3	4	5	6	7	I would not like to study technology at a university after high school	-29
Knowing about science will help me live a better life	1	2	3	4	5	6	7	Knowing about science will not help me to live a better life	-30
New technology has had a great effect on my family's way of living	1	2	3	4	5	6	7	New technology has had little or no effect on my family's way of living	-31
To be a good scientist you have to be a "workaholic"	1	2	3	4	5	6	7	You do not need to be a "workaholic" to be a good scientist	-32
A technologist usually gets paid more than a scientist	1	2	3	4	5	6	7	A scientist usually gets paid more than a technologist	-33
To do good science you have to remember a whole bunch of facts	1	2	3	4	5	6	7	To do good science you only have to know where to go for the information	-34
An engineer usually gets paid more than a scientist	1	2	3	4	5	6	7	A scientist usually gets paid more than an engineer	-35

Science has made life more complicated for everyone	1	2	3	4	5	6	7	Science has made life simpler for everyone	-36
A science course should concentrate on making the students more concerned about the environment	1	2	3	4	5	6	7	A science course should not concentrate on making the students more concerned about the environment	-37
I love working with technology	1	2	3	4	5	6	7	I hate working with technology	-38
I would like to study engineering after high school	1	2	3	4	5	6	7	I would not like to study engineering after high school	-39
It is hard for a scientist to believe in religion	1	2	3	4	5	6	7	Being a scientist has nothing to do with believing in religion	-40
Knowing science does not help one in everyday life	1	2	3	4	5	6	7	Knowing science does help one in everyday life	-41
The environment cannot be cleaned up without the help of science	1	2	3	4	5	6	7	The environment can be cleaned up without the help of science	-42
All scientists, no matter from what country, should share their knowledge with one another	1	2	3	4	5	6	7	Scientists should share their knowledge only with other scientists from their own country	-43

THANK YOU FOR YOUR HELP

44-78 Bl.

79-0
80-2

ONTARIO SCIENCE AND TECHNOLOGY SURVEY #8483
conducted by
MARKET FACTS OF CANADA LIMITED

Market Facts of Canada Limited
77 Bloor West, Toronto M5S 3A4
(416) 964-6262

Thank you very much for taking part in this survey among students in Ontario. The main purpose of this study is to find out how the present generation of high school students like yourself feel about matters related to science and technology.

In any effort to understand what science and technology mean to Canadians, the views of students are particularly important. You in fact represent Canada's future and your feelings today will influence attitudes towards various issues (like science and technology) in the years to come.

Please give us your opinion on each of the subjects in the questionnaire. There is no identification required. You are therefore assured of complete anonymity.

Please put your completed questionnaire in the envelope provided and seal it before handing it in. All envelopes will be opened and the questionnaires tabulated by Market Facts of Canada Limited to ensure the anonymity of those taking part in the survey.

INSTRUCTIONS FOR COMPLETING QUESTIONNAIRE

This questionnaire is made up of two parts. As you can see the first part is divided into a number of individual boxes, each containing 3 or 4 sentences.

Each box deals with one aspect of science and technology and the sentences in the box express different ideas or opinions on this. FOR EACH BOX, please read all the sentences and then circle the number next to the one that comes closest to your opinion.

In the lower half of each box, space has been provided for you to write in your feelings on the subject.

Before you go on to answer the questionnaire please complete the section below. This information is needed for tabulation only.

- -

Cd. 3

AGE in years ☐☐
6- 7-

SEX: Male ..... ☐1 -8
Female ... ☐2

GRADE/LEVEL:
Grade 10 Basic Science ...... ☐ 1 -9
Grade 10 General Science ... ☐ 2
Grade 10 Advanced Science . ☐ 3
Grade 12 Basic Science ...... ☐ 4
Grade 12 General Science ... ☐ 5
Grade 12 Advanced Science . ☐ 6

Name of school: ____________________ 10 bl.

Type of school: Public ☐1 Parochial ☐2 -11

City/town in which located: ____________________

12-
13-

14-1
15-2

16-19 bl.

1. -20

Science is explaining the unknown. 1

Science is using what we know to make the world a better place to live in. 2

Science is subjects like chemistry, physics and biology. 3

Science is a group of people (scientists) and what they believe. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

2. -21

Technology is how science is put to use. 1

Technology is using what we know to make the world a better place to live in. 2

Technology is machines and inventions. 3

Technology is machines and inventions as well as designing things. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

3. -22

If a new technology will do more harm than good to society, it will not be used. 1

If a new technology works well, is efficient and doesn't cost much, it will be used even if it does more harm than good to society. 2

Most new technologies are used, because some people benefit from them, even though others may see the harm they can do. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

4. -23

Scientists trained in one country look at scientific problems in different ways from scientists trained in another country, because their education and way of life are different. 1

Scientists are taught to look at scientific problems in the same way, no matter what countries the scientists are from, because science is the same all over the world. 2

Any two scientists may look at scientific problems differently. The country where they come from makes no difference. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

5. -24

When scientists are deciding whether or not to accept a theory:

- they look only at the facts. If the theory explains the facts, they accept it. If the theory cannot explain even just one fact, they do not accept the theory. 1
- they look at the facts and the theory. If a theory is simpler and/or more logical than other theories, they may accept it even if all the facts are not explained. 2
- they sometimes accept it for reasons that have nothing to do with how well it compares with other theories or how well it explains the facts. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

6. -25

Scientists who work for a profit-making company tend to put the company's interests ahead of doing the best science they can. 1

Scientists who work for a profit-making company put doing the best science they can ahead of the company's interests. 2

Some scientists who work for a profit-making company put doing the best science they can first; others put the company's interests first. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

BEST COPY AVAILABLE

7. -26

There are more men scientists than women scientists today:

- because boys are more interested in science than girls are. 1
- because boys are better at science than girls are. 2
- because until recently people used to believe that boys were better at science and that girls were better at other things, so more boys than girls made science their career. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

8. -27

If Canada spent more money on research in science and technology, Canada would become a wealthier country. 1

If Canada spent more money on research in science and technology, Canada might or might not become a wealthier country. It would depend on what science and technology were chosen. 2

If Canada spent more money on research in science and technology, Canada might become poorer, because other ways of making Canada wealthier would suffer. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

9. -28

Most scientists are doing science:

- to satisfy their own curiosity about the world around them. 1
- to be well known and/or rich. 2
- because they want to help people by finding new medical cures and solutions to environmental problems and by new inventions. 3
- because they want to be looked up to by other scientists. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

10. -29

The mass media (television, newspapers, magazines etc.) give you a better picture of what science is really like, than science classes do. 1

Neither the mass media, nor science classes, give you a good picture of what science is really like. 2

Science classes give you a better picture of what science is really like, than the mass media do. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

11. -30

Science classes have helped me become a better shopper, because I can use the scientific method and/or scientific facts to help me decide which products to buy. 1

Science classes have not helped me become a better shopper. Neither the scientific method nor scientific facts can possibly help me decide which products to buy. 2

Science classes have not helped me become a better shopper. Even though science teaches the scientific method and valuable facts, people like me tend to buy things they see on television or in advertisements. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

12. -31

Women scientists might make different discoveries from those made by men scientists, because women have different feelings and experiences from men. 1

Women scientists and men scientists are all scientists, so they make the same kind of discoveries. 2

Different discoveries made by different scientists have nothing to do with whether the scientists are men or women. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

BEST COPY AVAILABLE

13. -32

Science and technology will not be able to solve problems caused by pollution, because the problems are so bad that it would cost too much. 1

Science and technology alone cannot solve problems caused by pollution. 2

Science and technology can solve problems caused by pollution, because science and technology have been successful in solving problems in the past. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

14. -33

We have to accept both the good and the bad effects of technology, because every new development has at least one bad effect, and to enjoy the good ones we have to put up with the bad ones. 1

We don't have to accept the bad effects of technology, because bad effects can be reduced or removed through careful planning and testing. 2

We don't have to accept the bad effects of technology, because some new developments have no bad effects and we should use those ones only. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

15. -34

Scientists and engineers should decide what types of energy (such as nuclear, hydro, solar etc.) Canada will use in the future, because they know best. 1

Everybody should be involved in deciding what types of energy Canada will use in the future, because we are all affected by the decision. 2

People other than scientists and engineers should decide what types of energy Canada will use in the future, because the decision is a social and economic one, not a technical one. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

35-78 Bl.

79-0
80-3

BEST COPY AVAILABLE

Cd.4

Below are some pairs of opposite statements. Please read each pair, then circle the number which best describes your opinion. The closer the number is to one of the statements, the more you agree with that statement.

16-19 Bl.

All scientists, no matter from what country, should share their knowledge with one another	1	2	3	4	5	6	7	Scientists should share their knowledge only with other scientists from their own country	-20
The environment cannot be cleaned up without the help of science	1	2	3	4	5	6	7	The environment can be cleaned up without the help of science	-21
Knowing science does not help one in everyday life	1	2	3	4	5	6	7	Knowing science does help one in everyday life	-22
It is hard for a scientist to believe in religion	1	2	3	4	5	6	7	Being a scientist has nothing to do with believing in religion	-23
I would like to study engineering after high school	1	2	3	4	5	6	7	I would not like to study engineering after high school	-24
I love working with technology	1	2	3	4	5	6	7	I hate working with technology	-25
A science course should concentrate on making the students more concerned about the environment	1	2	3	4	5	6	7	A science course should not concentrate on making the students more concerned about the environment	-26
Science has made life more complicated for everyone	1	2	3	4	5	6	7	Science has made life simpler for everyone	-27
An engineer usually gets paid more than a scientist	1	2	3	4	5	6	7	A scientist usually gets paid more than an engineer	-28
To do good science you have to remember a whole bunch of facts	1	2	3	4	5	6	7	To do good science you only have to know where to go for the information	-29
A technologist usually gets paid more than a scientist	1	2	3	4	5	6	7	A scientist usually gets paid more than a technologist	-30
To be a good scientist you have to be a "workaholic"	1	2	3	4	5	6	7	You do not need to be a "workaholic" to be a good scientist	-31
New technology has had a great effect on my family's way of living	1	2	3	4	5	6	7	New technology has had little or no effect on my family's way of living	-32
Knowing about science will help me live a better life	1	2	3	4	5	6	7	Knowing about science will not help me to live a better life	-33
I would like to study technology at a university after high school	1	2	3	4	5	6	7	I would not like to study technology at a university after high school	-34
Government agencies should be the ones to tell scientists what to do research on	1	2	3	4	5	6	7	Scientists themselves should be the ones to decide what to do research on	-35

BEST COPY AVAILABLE

I do not like all the detail that goes into learning science	1	2	3	4	5	6	7	I love all the detail that goes into learning science	-36
Most scientists seem to be "absent-minded" professors	1	2	3	4	5	6	7	Most scientists seem to be just like other people	-37
To improve our quality of living, Canada should spend more on technological and scientific research, than on education and welfare	1	2	3	4	5	6	7	To improve our quality of living, Canada should spend more on education and welfare, than on technological and scientific research	-38
I'm glad I have had to learn at least some science	1	2	3	4	5	6	7	I wish I had never had to learn any science	-39
Other people look up to scientists more than they do to, say, businesspeople	1	2	3	4	5	6	7	Other people look up to, say, businesspeople more than they do to scientists	-40
I'm more interested in people than in technology	1	2	3	4	5	6	7	I'm more interested in technology than in people	-41
Women scientists tend to be too aggressive	1	2	3	4	5	6	7	Women scientists are no more nor less aggressive than other women	-42
Studying science has made me more interested in issues such as pollution	1	2	3	4	5	6	7	Studying science has not made me more interested in issues such as pollution	-43

THANK YOU FOR YOUR HELP

44-78 Bl.

79-0
80-4

ONTARIO SCIENCE AND TECHNOLOGY SURVEY #B483
conducted by
MARKET FACTS OF CANADA LIMITED

Market Facts of Canada Limited
77 Bloor West, Toronto M5S 3A4
(416) 964-6262

Thank you very much for taking part in this survey among students in Ontario. The main purpose of this study is to find out how the present generation of high school students like yourself feel about matters related to science and technology.

In any effort to understand what science and technology mean to Canadians, the views of students are particularly important. You in fact represent Canada's future and your feelings today will influence attitudes towards various issues (like science and technology) in the years to come.

Please give us your opinion on each of the subjects in the questionnaire. There is no identification required. You are therefore assured of complete anonymity.

Please put your completed questionnaire in the envelope provided and seal it before handing it in. All envelopes will be opened and the questionnaires tabulated by Market Facts of Canada Limited to ensure the anonymity of those taking part in the survey.

INSTRUCTIONS FOR COMPLETING QUESTIONNAIRE

This questionnaire is made up of two parts. As you can see the first part is divided into a number of individual boxes, each containing 3 or 4 sentences.

Each box deals with one aspect of science and technology and the sentences in the box express different ideas or opinions on this. FOR EACH BOX, please read all the sentences and then circle the number next to the one that comes closest to your opinion.

In the lower half of each box, space has been provided for you to write in your feelings on the subject.

Before you go on to answer the questionnaire please complete the section below. This information is needed for tabulation only.

- -

Cd. 5

AGE in years ☐☐
6- 7-

SEX: Male ..... ☐1 -8
Female ... ☐2

GRADE/LEVEL:
Grade 10 Basic Science ...... ☐ 1 -9
Grade 10 General Science ... ☐ 2
Grade 10 Advanced Science . ☐ 3
Grade 12 Basic Science ...... ☐ 4
Grade 12 General Science ... ☐ 5
Grade 12 Advanced Science . ☐ 6

10 bl.

Name of school: ____________________

Type of school: Public ☐1 Parochial ☐2 -11

City/town in which located: ____________________

12-
13-

14-1
15-3

16-19 bl.

1. -20

Science is explaining the unknown. 1

Science is using what we know to make the world a better place to live in. 2

Science is subjects like chemistry, physics and biology. 3

Science is a group of people (scientists) and what they believe. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

2. -21

Technology is how science is put to use. 1

Technology is using what we know to make the world a better place to live in. 2

Technology is machines and inventions. 3

Technology is machines and inventions as well as designing things. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

3. -22

A scientific model is a copy of the real thing. 1

A scientific model is very much like the real thing. 2

A scientific model is not like the real thing, but is useful for explaining the real thing. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

4. -23

Scientific knowledge never changes. 1

Scientific knowledge can change only if new research proves earlier research to be wrong. 2

Scientific knowledge can change if earlier research is looked at in a different way. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

5. -24

The best scientists always follow the steps of the scientific method. 1

The best scientists sometimes do and sometimes do not follow the steps of the scientific method. 2

The best scientists never follow the steps of the scientific method. They are clever enough so they don't need to. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

6. -25

Scientists write about their work in an organized way and in a certain order:

- they also do their work in an organized way, and in the same order in which they write about it. 1
- they do their work in an organized way, but not in the same order in which they write about it. 2
- they do not usually do their work in an organized way. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

BEST COPY AVAILABLE

7. -26

Scientific mistakes only slow down the progress of science. 1

Scientific mistakes sometimes lead to new discoveries and therefore science progresses. 2

Finding and correcting scientific mistakes is the only way science progresses. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

8. -27

Even with accurate information, scientists and engineers can tell us only what will probably happen, not what will definitely happen. 1

Scientists and engineers can tell us what will definitely happen if they have enough accurate information. 2

There's no way scientists and engineers can ever tell us even what will probably happen, no matter how much accurate information they have. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

9. -28

If scientists find that people working with a certain material have twice as much chance of getting lung cancer as do other people:

- this means that the material causes lung cancer and it should not be used. 1
- this does not necessarily mean that the material causes lung cancer and it could still be used. 2
- this does not necessarily mean that the material causes lung cancer. However, more research should be done before the material is used again. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

10. -29

Science is needed in order to invent new technology. 1

New technology can be invented without science. 2

Science is basically the same thing as technology. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

11. -30

Good scientists rarely use reference materials, as they can almost always remember information when they need it. 1

Good scientists often use reference materials to look up information when they need it. 2

Good scientists almost always use reference materials to look up information when they need it. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

12. -31

Members of Parliament do not need to know anything about science and technology to do their job, because science and technology have nothing to do with their work. 1

Members of Parliament need to know about science and technology in order to make good decisions about Canada's future. 2

Members of Parliament do not need to know anything about science and technology because they can always rely on scientists and engineers for advice. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

BEST COPY AVAILABLE

13. -32

When you solve a problem in daily life you are doing science. 1

When you solve a problem in daily life sometimes you are doing science and sometimes not. It depends on the type of problem. 2

When you solve a problem in daily life, you are not doing science because science has nothing to do with everyday life. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

14. -33

The only way of knowing about the world is through science. 1

Science is one of many good ways of knowing something about the world. Science alone however is not enough to know all about the world. 2

Science is the best way of knowing about the world, even though there are other ways of knowing about it. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

15. -34

When new technology is invented, it often leads to new scientific facts and theories. 1

New technology can be invented only by using known scientific facts and theories. 2

New technology is often invented without using scientifc facts and theories. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

16. -35

Learning the steps of the scientific method is good for doing science and for solving problems in daily life. 1

Learning the steps of the scientific method is good only for doing science and not for solving problems in daily life. 2

Learning the steps of the scientific method is a waste of time as it serves no useful purpose in science or in daily life. 3

Learning the steps of the scientific method may be good for solving problems in daily life, and may or may not be good for doing science. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

36-78 Bl.

79-0
80-5

BEST COPY AVAILABLE

Cd.6

Below are some pairs of opposite statements. Please read each pair, then circle the number which best describes your opinion...The closer the number is to one of the statements, the more you agree with that statement.

16-19 Bl.

If you don't know computers you won't be able to get a good job	1	2	3	4	5	6	7	If you don't know computers you will be able to get a good job	-20
Science is very easy to learn	1	2	3	4	5	6	7	Science is very hard to learn	-21
I would love to be a scientist	1	2	3	4	5	6	7	I would hate to be a scientist	-22
I like to solve problems with other people's help	1	2	3	4	5	6	7	I like to solve problems by myself	-23
There's too much high-tech stuff already	1	2	3	4	5	6	7	There's not enough high-tech stuff yet	-24
I would rather be a technologist than a scientist	1	2	3	4	5	6	7	I would rather be a scientist than a technologist	-25
You need to learn science only if you are going to be a scientist or a science teacher	1	2	3	4	5	6	7	You need to learn science no matter what you are going to be	-26
Learning science helps people think for themselves	1	2	3	4	5	6	7	Being able to think for yourself has nothing to do with having learned science	-27
Science has done much more good than harm	1	2	3	4	5	6	7	Science has done much more harm than good	-28
More technology means fewer jobs for people	1	2	3	4	5	6	7	More technology means different but not fewer jobs for people	-29
I'd much rather work with animals and nature than in an office or lab	1	2	3	4	5	6	7	I'd much rather work in an office or lab than with animals or nature	-30
Being a scientist means you'll make a lot of money	1	2	3	4	5	6	7	Being a scientist means you might not make a lot of money	-31
I love to read books that make me think	1	2	3	4	5	6	7	I love to read books that don't make me think	-32
I would like to study technology at a community college after high school	1	2	3	4	5	6	7	I would not like to study technology at a community college after high school	-33
I love to find out how things work	1	2	3	4	5	6	7	As long as things work, I don't care how they do it	-34
Science is important for everything in daily life	1	2	3	4	5	6	7	Science has nothing to do with anything in daily life	-35

People who choose jobs in technology are smarter than people who choose jobs in science	1	2	3	4	5	6	7	People who choose jobs in science are smarter than people who choose jobs in technology	-36
You have to be a genius to be a scientist	1	2	3	4	5	6	7	You don't have to be a genius to be a scientist	-37
Scientists have feelings	1	2	3	4	5	6	7	Scientists have no feelings	-38
Being an engineer means you might not make a lot of money	1	2	3	4	5	6	7	Being an engineer means you'll make a lot of money	-39
Canada needs to have more scientists and engineers	1	2	3	4	5	6	7	Canada already has too many scientists and engineers	-40
You have to have learned science to get a good job	1	2	3	4	5	6	7	You don't have to have learned science to get a good job	-41
Science is a very personal thing	1	2	3	4	5	6	7	Science is not a very personal thing	-42
Scientists are just as creative as artists	1	2	3	4	5	6	7	Artists are creative, scientists aren't	-43
Community colleges are not as good as universities for someone who wants a good job	1	2	3	4	5	6	7	Universities are not as good as community colleges for someone who wants a good job	-44

THANK YOU FOR YOUR HELP

45-78 Bl.

79-0
80-6

ONTARIO SCIENCE AND TECHNOLOGY SURVEY #B483
conducted by
MARKET FACTS OF CANADA LIMITED

Market Facts of Canada Limited
77 Bloor West, Toronto M5S 3A4
(416) 964-6262

Thank you very much for taking part in this survey among students in Ontario. The main purpose of this study is to find out how the present generation of high school students like yourself feel about matters related to science and technology.

In any effort to understand what science and technology mean to Canadians, the views of students are particularly important. You in fact represent Canada's future and your feelings today will influence attitudes towards various issues (like science and technology) in the years to come.

Please give us your opinion on each of the subjects in the questionnaire. There is no identification required. You are therefore assured of complete anonymity.

Please put your completed questionnaire in the envelope provided and seal it before handing it in. All envelopes will be opened and the questionnaires tabulated by Market Facts of Canada Limited to ensure the anonymity of those taking part in the survey.

INSTRUCTIONS FOR COMPLETING QUESTIONNAIRE

This questionnaire is made up of two parts. As you can see the first part is divided into a number of individual boxes, each containing 3 or 4 sentences.

Each box deals with one aspect of science and technology and the sentences in the box express different ideas or opinions on this. FOR EACH BOX, please read all the sentences and then circle the number next to the one that comes closest to your opinion.

In the lower half of each box, space has been provided for you to write in your feelings on the subject.

Before you go on to answer the questionnaire please complete the section below. This information is needed for tabulation only.

- -

Cd. 7

AGE in years ☐☐
6- 7-

SEX: Male ..... ☐1 -8
Female ... ☐2

GRADE/LEVEL:
Grade 10 Basic Science ...... ☐ 1 -9
Grade 10 General Science ... ☐ 2
Grade 10 Advanced Science . ☐ 3
Grade 12 Basic Science ...... ☐ 4
Grade 12 General Science ... ☐ 5
Grade 12 Advanced Science . ☐ 6

Name of school: ______________________________ 10 bl.

Type of school: Public ☐1 Parochial ☐2 -11

City/town in which located: ______________________________

12-
13-

14-1
15-4

16-19 bl.

1.

-20

Science is explaining the unknown. 1

Science is using what we know to make the world a better place to live in. 2

Science is subjects like chemistry, physics and biology. 3

Science is a group of people (scientists) and what they believe. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

2.

-21

Technology is how science is put to use. 1

Technology is using what we know to make the world a better place to live in. 2

Technology is machines and inventions. 3

Technology is machines and inventions as well as designing things. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

3.

-22

Learning the steps of the scientific method is good for doing science and for solving problems in daily life. 1

Learning the steps of the scientific method is good only for doing science and not for solving problems in daily life. 2

Learning the steps of the scientific method is a waste of time as it serves no useful purpose in science or in daily life. 3

Learning the steps of the scientific method may be good for solving problems in daily life, and may or may not be good for doing science. 4

My own feelings on this subject are ...
(PLEASE WRITE IN)

4.

-23

When new technology is invented, it often leads to new scientific facts and theories. 1

New technology can be invented only by using known scientific facts and theories. 2

New technology is often invented without using scientifc facts and theories. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

5.

-24

The only way of knowing about the world is through science. 1

Science is one of many good ways of knowing something about the world. Science alone however is not enough to know all about the world. 2

Science is the best way of knowing about the world, even though there are other ways of knowing about it. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

6.

-25

When you solve a problem in daily life you are doing science. 1

When you solve a problem in daily life sometimes you are doing science and sometimes not. It depends on the type of problem. 2

When you solve a problem in daily life, you are not doing science because science has nothing to do with everyday life. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

BEST COPY AVAILABLE

7. -26

Members of Parliament do not need to know anything about science and technology to do their job, because science and technology have nothing to do with their work. 1

Members of Parliament need to know about science and technology in order to make good decisions about Canada's future. 2

Members of Parliament do not need to know anything about science and technology because they can always rely on scientists and engineers for advice. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

8. -27

Good scientists rarely use reference materials, as they can almost always remember information when they need it. 1

Good scientists often use reference materials to look up information when they need it. 2

Good scientists almost always use reference materials to look up information when they need it. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

9. -28

Science is needed in order to invent new technology. 1

New technology can be invented without science. 2

Science is basically the same thing as technology. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

10. -29

If scientists find that people working with a certain material have twice as much chance of getting lung cancer as do other people:

- this means that the material causes lung cancer and it should not be used. 1
- this does not necessarily mean that the material causes lung cancer and it could still be used. 2
- this does not necessarily mean that the material causes lung cancer. However, more research should be done before the material is used again. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

11. -30

Even with accurate information, scientists and engineers can tell us only what will probably happen, not what will definitely happen. 1

Scientists and engineers can tell us what will definitely happen if they have enough accurate information. 2

There's no way scientists and engineers can ever tell us even what will probably happen, no matter how much accurate information they have. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

12. -31

Scientific mistakes only slow down the progress of science. 1

Scientific mistakes sometimes lead to new discoveries and therefore science progresses. 2

Finding and correcting scientific mistakes is the only way science progresses. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

BEST COPY AVAILABLE

13. -32

Scientists write about their work in an organized way and in a certain order:

- they also do their work in an organized way, and in the same order in which they write about it. 1
- they do their work in an organized way, but not in the same order in which they write about it. 2
- they do not usually do their work in an organized way. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

14. -33

The best scientists always follow the steps of the scientific method. 1

The best scientists sometimes do and sometimes do not follow the steps of the scientific method. 2

The best scientists never follow the steps of the scientific method. They are clever enough so they don't need to. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

15. -34

Scientific knowledge never changes. 1

Scientific knowledge can change only if new research proves earlier research to be wrong. 2

Scientific knowledge can change if earlier research is looked at in a different way. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

16. -35

A scientific model is a copy of the real thing. 1

A scientific model is very much like the real thing. 2

A scientific model is not like the real thing, but is useful for explaining the real thing. 3

My own feelings on this subject are ...
(PLEASE WRITE IN)

36-78 Bl.

79-0
80-7

BEST COPY AVAILABLE

Cd.8

Below are some pairs of opposite statements. Please read each pair, then circle the number which best describes your opinion. The closer the number is to one of the statements, the more you agree with that statement.

16-19 Bl.

Community colleges are not as good as universities for someone who wants a good job	1	2	3	4	5	6	7	Universities are not as good as community colleges for someone who wants a good job	-20
Scientists are just as creative as artists	1	2	3	4	5	6	7	Artists are creative, scientists aren't	-21
Science is a very personal thing	1	2	3	4	5	6	7	Science is not a very personal thing	-22
You have to have learned science to get a good job	1	2	3	4	5	6	7	You don't have to have learned science to get a good job	-23
Canada needs to have more scientists and engineers	1	2	3	4	5	6	7	Canada already has too many scientists and engineers	-24
Being an engineer means you might not make a lot of money	1	2	3	4	5	6	7	Being an engineer means you'll make a lot of money	-25
Scientists have feelings	1	2	3	4	5	6	7	Scientists have no feelings	-26
You have to be a genius to be a scientist	1	2	3	4	5	6	7	You don't have to be a genius to be a scientist	-27
People who choose jobs in technology are smarter than people who choose jobs in science	1	2	3	4	5	6	7	People who choose jobs in science are smarter than people who choose jobs in technology	-28
Science is important for everything in daily life	1	2	3	4	5	6	7	Science has nothing to do with anything in daily life	-29
I love to find out how things work	1	2	3	4	5	6	7	As long as things work, I don't care how they do it	-30
I would like to study technology at a community college after high school	1	2	3	4	5	6	7	I would not like to study technology at a community college after high school	-31
I love to read books that make me think	1	2	3	4	5	6	7	I love to read books that don't make me think	-32
Being a scientist means you'll make a lot of money	1	2	3	4	5	6	7	Being a scientist means you might not make a lot of money	-33
I'd much rather work with animals and nature than in an office or lab	1	2	3	4	5	6	7	I'd much rather work in an office or lab than with animals or nature	-34
More technology means fewer jobs for people	1	2	3	4	5	6	7	More technology means different but not fewer jobs for people	-35

Science has done much more good than harm	1	2	3	4	5	6	7	Science has done much more harm than good	-36
Learning science helps people think for themselves	1	2	3	4	5	6	7	Being able to think for yourself has nothing to do with having learned science	-37
You need to learn science only if you are going to be a scientist or a science teacher	1	2	3	4	5	6	7	You need to learn science no matter what you are going to be	-38
I would rather be a technologist than a scientist	1	2	3	4	5	6	7	I would rather be a scientist than a technologist	-39
There's too much high-tech stuff already	1	2	3	4	5	6	7	There's not enough high-tech stuff yet	-40
I like to solve problems with other people's help	1	2	3	4	5	6	7	I like to solve problems by myself	-41
I would love to be a scientist	1	2	3	4	5	6	7	I would hate to be a scientist	-42
Science is very easy to learn	1	2	3	4	5	6	7	Science is very hard to learn	-43
If you don't know computers you won't be able to get a good job	1	2	3	4	5	6	7	If you don't know computers you will be able to get a good job	-44

THANK YOU FOR YOUR HELP

45-78 Bl.

79-0
80-8

APPENDIX "B"

EXHIBITS

40211 (MC5)

EXHIBIT 1

Scientists and engineers should be the ones to decide what types of energy (e.g., nuclear, hydroelectric, solar, coal etc.) because they are the ones who know best.

Agree completely	☐ 1	- because ---	they have the training and facts and therefore know best	☐ 1
		- because ---	they can make better decisions than government or business who think of themselves first	☐ 2
Agree	☐ 2	- but -------	the public should be involved	☐ 3
Agree partly	☐ 3	- because ---	the public should have an equal say in everything that affects Canadians	☐ 4
Disagree	☐ 4	- because ---	the government should decide with advice from scientists and engineers	☐ 5
		- because ---	the public should decide with advice from scientists and engineers	☐ 6
		- because ---	the public only should decide. Scientists are narrow-minded and don't think about the consequences	☐ 7
I don't know	☐ 5			
I don't care	☐ 6			

What I think about the statement at the top of the page is ... (PLEASE WRITE IN IN YOUR OWN WORDS)

EXHIBIT 2

10421

IN ORDER TO IMPROVE OUR QUALITY OF LIVING, CANADA SHOULD SPEND MONEY ON TECHNOLOGICAL RESEARCH RATHER THAN SCIENTIFIC RESEARCH

1. *Please CIRCLE ONE NUMBER below to show how much you agree or disagree with the statement in the box.*

Agree completely	Tend to agree	Tend to disagree	Disagree completely	I don't know	I don't care
1	2	3	4	5	6

2. *Which sentence below best describes your feelings? (CIRCLE ONE NUMBER)*

Canada should spend money on both, because each in its own way helps the quality of living	1
Canada should spend more money on scientific research than on technological research	2
Canada should spend money on both because technology can not improve without science	3
Canada should spend money on both because science and technology help each other equally	4
Canada should not spend money on either type of research	5
Canada should spend more money on technological research than on scientific research	6
I don't agree with any of these sentences	7

3. What I think about the statement at the top of the page is ... (PLEASE WRITE IN YOUR OWN WORDS)

10421 In order to improve the quality of living in Canada, it would be better to invest money in technological research RATHER THAN scientific research.

Eng	Fr %	Your position, basically:
3	2	A. Invest in technological research because it will improve production, economic growth, and unemployment. These are far more important than anything that scientific research has to offer.
		Invest in both:
1	2	B. because there is really no difference between science and technology.
15	17	C. because scientific knowledge is needed to make technological advances.
24	25	D. because they interact and complement each other equally. Technology gives as much to science as science gives to technology.
44	38	E. because each in its own way brings advantages to society. For example, science brings medical and environmental advances, while technology brings improved conveniences and efficiency.
2	5	F. Invest in scientific research — that is, medical or environmental research — because these are more important than making better appliances, computers or other products of technological research.
5	8	G. Invest in scientific research because it improves the quality of life (e.g., medical cures, answers to pollution, and increased knowledge). Technological research, on the other hand, has worsened the quality of life (e.g., atomic bombs, pollution, automation, etc.).
2	1	H. Invest in neither. The quality of living will not improve with advances in science and technology, but will improve with investments in other sectors of society (e.g., social welfare, education, job creation programs, the fine arts, foreign aid, etc.).
1	1	I. I don't understand.
4	4	J. I don't know enough about this subject to make a choice.
1	1	K. None of these choices fits my basic viewpoint.

BEST COPY AVAILABLE

EXHIBIT 3

SCHOOLS OFFERING GRADES 10 AND 12 SCIENCE COURSES

		English	French	Total
Central Ontario	Public	282	6	288
	Separate	72	1	73
Eastern Ontario	Public	65	10	75
	Separate	13	5	18
Midnorthern Ontario	Public	22	8	30
	Separate	4	2	6
Northeastern Ontario	Public	22	3	25
	Separate	2	6	8
Northwestern Ontario	Public	19	1	20
	Separate	3	-	3
Western Ontario	Public	81	1	82
	Separate	12	2	14
TOTAL	Public	491	29	520
	Separate	106	16	122

EXHIBIT 4

SCHOOLS HAVING 20+ STUDENTS IN EACH OF GRADES 10 AND 12
(IN A GIVEN SCIENCE COURSE LEVEL)

		English	French	Total
Central Ontario	Public	246	3	249
	Separate	61	-	61
Eastern Ontario	Public	54	7	61
	Separate	11	5	16
Midnorthern Ontario	Public	17	3	20
	Separate	2	1	3
Northeastern Ontario	Public	17	-	17
	Separate	1	5	6
Northwestern Ontario	Public	13	-	13
	Separate	1	-	1
Western Ontario	Public	70	-	70
	Separate	10	1	11
TOTAL	Public	417	12	429
	Separate	86	12	98

EXHIBIT 5

INITIAL SELECTION OF SAMPLE SCHOOLS

		English	French	Total
Central Ontario	Public	15	1	16
	Separate	7	-	7
Eastern Ontario	Public	4	4	8
	Separate	1	4	5
Midnorthern Ontario	Public	2	1	3
	Separate	-	1	1
Northeastern Ontario	Public	2	-	2
	Separate	-	3	3
Northwestern Ontario	Public	1	-	1
	Separate	-	-	-
Western Ontario	Public	6	-	6
	Separate	2	1	3
TOTAL	Public	30	5	35
	Separate	10	9	19

EXHIBIT 6

FINAL DISTRIBUTION OF TEST SITES

		English	French	Total
Central Ontario	Public	12	1	13
	Separate	3	-	3
Eastern Ontario	Public	2	-	2
	Separate	-	4	4
Midnorthern Ontario	Public	-	1	1
	Separate	-	1	1
Northeastern Ontario	Public	1	-	1
	Separate	-	3	3
Northwestern Ontario	Public	1	-	1
	Separate	-	-	-
Western Ontario	Public	5	-	5
	Separate	1	1	2
TOTAL	Public	21	2	23
	Separate	4	9	13

EXHIBIT 7

EXPECTED STUDENT SAMPLES FROM TEST SITES

Grade/Science Level	English	French
Grade 10 Basic	121	-
Grade 10 General	210	105
Grade 10 Advanced	357	212
Grade 12 Basic	111	-
Grade 12 General	187	103
Grade 12 Advanced	340	208
	1,326	628

EXHIBIT 8

FINAL STUDENT SAMPLES

Grade/Science Level	English	French
Grade 10 Basic	97	-
Grade 10 General	129	81
Grade 10 Advanced	290	173
Grade 12 Basic	69	-
Grade 12 General	116	60
Grade 12 Advanced	225	152
	956	466

EXHIBIT 9
(page 1 of 4)

Market Facts OF CANADA LIMITED
A Total Service in Marketing Research

February 28, 1990

Principal

NORTH YORK, Ontario

Dear

Re: STS STUDY #B483

This is with regard to my discussion with you and subsequent letter regarding the above study. I am sending herewith the required questionnaires for the above survey.

Separate sets of questionnaires together with envelopes have been made out for the required number of students at each Grade/science level as indicated in my earlier letter. To confirm, these are as follows:

Grade/Level	Number
Grade 10 science Basic	-
Grade 12 science Basic	-
Grade 10 science General	-
Grade 12 science General	-
Grade 10 science Advanced	31
Grade 12 science Advanced	25

The enclosed questionnaires and envelopes are to be handed out to the participating students. There are differenct versions of the questionnaire which have already been arranged in a particular order. The teacher administering the questionnaire would only have to hand these out in the same order in which they are presently stacked.

The questionnaires also contain a brief background of the study and completion instructions. Students have been requested to put the questionnaires in the envelopes and staple or seal the latter - primarily in order to reassure them that there is no possibility of their questionnaires and the answers there being identified and traced back to them. By so doing, we expect to improve the quality of their responses.

Although the respondents have been asked to fill in their grade and science course level (general or advanced) in the questionnaire itself, I would appreciate it if all envelopes with completed questionnaires from a particular Grade/level could be banded together and the Grade/level indicated on the topmost (or any) envelope.

/ ...2

77 Bloor Street West
12th Floor
Toronto, Ontario
M5S 3A4
(416) 964-6262
Telex: 06217698
Fax: (416) 964-5882

Toronto
Montreal
Vancouver
Edmonton

Chicago
New York
Washington, D.C.

Los Angeles
Dallas
Boston

CAMRO MEMBER

EXHIBIT 9
(page 2 of 4)

The questionnaires are to be administered before the spring break, or in the week immediately after i.e. by March 23.

Once the study at your school has been completed, could you please send the completed questionnaires back to us through FEDERAL EXPRESS. I am enclosing here a waybill. This will ensure that your school is not charged for the courier service - the charges will be borne by us on receipt of the questionnaires.

Together with the completed questionnaires could you please also send me a letter stating that the required parent consents for the above study had been obtained.

Once again, thank you very much for your co-operation in this project. If there are any clarifications you need please do not hesitate to get in touch with me. I look forward to the successful completion of the project in your school.

Yours sincerely,

Sheila Kumar

Sheila Kumar
Senior Project Director

SK/mp

Enclosure

APPENDIX "C"

SAMPLES FROM VOSTS

SAMPLE QUESTIONS FROM VIEWS ON SCIENCE, TECHNOLOGY AND SOCIETY (VOSTS)

90521 When developing new theories or laws, scientists need to make certain assumptions about nature (for example, matter is made up of atoms). These assumptions must be true in order for science to progress properly.

Your position basically: (please read from A to I, and then choose one.)

Assumptions MUST be true in order for science to progress:

A. because correct assumptions are needed for correct theories and laws. Otherwise scientists would waste a lot of time and effort using wrong theories and laws.

B. otherwise society would have serious problems, such as inadequate technology and dangerous chemicals.

C. because scientists do research to prove their assumptions true before going on with their work.

D. It depends. Sometimes science needs true assumptions in order to progress. But sometimes history has shown that great discoveries have been made by disproving a theory and learning from its false assumptions.

E. It doesn't matter. Scientists have to make assumptions, true or not, in order to get started on a project. History has shown that great discoveries have been made by disproving a theory and learning from its false assumptions.

F. Scientists do not make assumptions. They research an idea to find out if the idea is true. They don't assume it is true.

G. I don't understand.

H. I don't know enough about this subject to make a choice.

I. None of these choices fits my basic viewpoint.

10211 Defining what technology is, can cause difficulties because technology does many things in Canada. But MAINLY technology is:

Your position basically: (please read from A to J, and then choose one.)

A. very similar to science.

B. the application of science.

C. new processes, instruments, tools, machinery, appliances, gadgets, computers, or practical devices for everyday use.

D. robotics, electronics, computers, communication systems, automation, etc..

E. a technique for doing things, or a way of solving practical problems.

F. inventing, designing and testing things (for example, artificial hearts, computers, space vehicles).

G. ideas and techniques for designing and manufacturing things, for organizing workers, business people and consumers, for the progress of society.

H. I don't understand

I. I don't know enough about this subject to make a choice.

J. None of these choices fits my basic viewpoint.

Printed on recycled paper

BEST COPY AVAILABLE

SE 054765

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

ERIC®

NOTICE

REPRODUCTION BASIS

☑ This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

☐ This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").

(9/92)